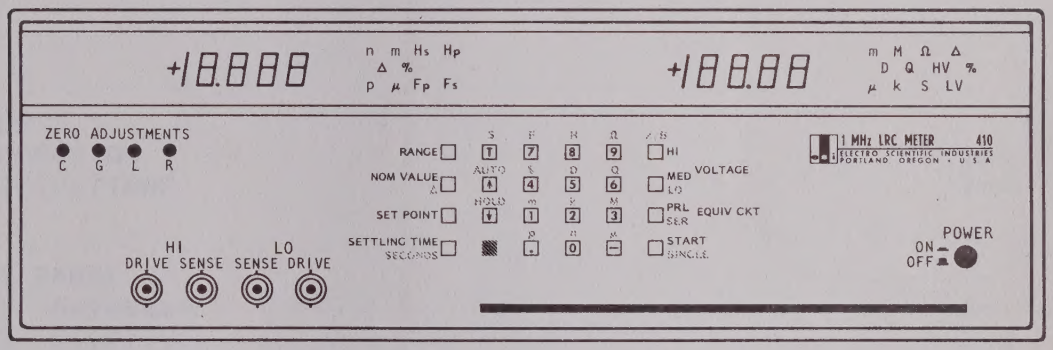
Instruction Manual

JANUARY 1979
Replaces November 1978

MODEL 410

1 MHz LRC Meter



Part Number 43311

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WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN BIAS SUPPLIES ARE CONNECTED TO THIS INSTRUMENT. WHEN EXTERNAL BIAS SUPPLIES ARE ATTACHED, THE BIAS VOLTAGES ARE PRESENT ON BOTH FRONT AND REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO ±200VDC WITH EACH BIAS SUPPLY CURRENT LIMITED AT 100mA. DO NOT TOUCH, CONNECT OR DISCONNECT THE UNKNOWN OR BNC CABLES WHILE BIAS VOLTAGES ARE APPLIED.

WARNING

INFORMATION IN THIS SECTION IS FOR QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE UNLESS YOU ARE QUALIFIED TO DO SO.

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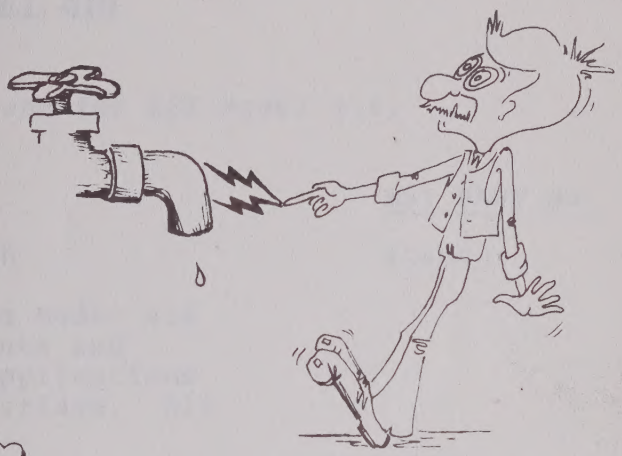
PROTECT AGAINST ELECTROSTATIC DISCHARGE

In this instrument there are MOS and FET semiconductors, which can be damaged by electrostatic discharge during handling. The following precautionary procedures are recommended to minimize this possibility.



DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES

HANDLE STATIC SENSITIVE DEVICES ONLY AT A GROUNDED, STATIC-FREE WORK STATION

HANDLE DEVICES BY THE BODY. DO NOT TOUCH THE DEVICE LEADS.

BE SURE YOUR SOLDERING IRON TIP IS GROUNDED AND DO NOT USE SOLDER-SUCKERS THAT ARE NOT ANTI—STATIC PROTECTED

AVOID HANDLING WHENEVER POSSIBLE

USE ANTI-STATIC PACKAGING FOR HANDLING AND TRANSPORT

KEEP PARTS IN MANUFACTURER'S PROTECTED CONTAINERS

DO NOT SLIDE STATIC SENSITIVE DEVICES OVER ANY SURFACE AND AVOID PLASTIC, VINYL AND STYROFOAM IN WORK AREAS

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ADDENDUM

MODEL 410

Following is a list of plug-in options for ESI Model 410.

OPTION	ESI PART NO.
General Purpose Interface Bus Option	42404

The general purpose interface allows Model 410 to be connected with other instruments and controllers for automatic testing applications It is an IEEE 488-1975 standard interface. All front panel functions are available.

Handler Interface Kits	42436 44339 44340

Handler interface kits enable Model 410 to operate with automatic part sorting equipment. The three standard handler interface kits available are:

- 42436 - For interfacing the Engineered Automation Auto-Sort handler to the Model 410 via an ESI Model 1453 Handler Adapter.
- 44339 - For interfacing Daymarc Type 147 and 149 handlers directly to the Model 410.
- 44340 - For interfacing Deval component handlers to the Model 410.

Consult factory for information concerning the use of other handlers with the Model 410.

Teletype Interface Option	42735

The Teletype Interface option enables Model 410 to interface with 20mA current loop systems, 5V TTL level systems, RS 232, ±12V switched at ground systems or any three-wire serial bus system.

Card Reader Interface Option	42736

The Card Reader Interface option allows Model 410 to be programmed remotely with an HP11301 Hollerith card reader and specially marked Hollerith cards.

SECTION 1
DESCRIPTION

1.1 INTRODUCTION

Model 410 is a microprocessor-controlled automatic LRC meter. It measures and calculates L, C, X or B and R, G, D or Q. Two 4-1/2 digit readouts simultaneously display the reactive and loss components of the unknown. Measurement function programming is performed with the 24-button front panel keyboard. Dual function buttons similar to those used in pocket calculators simplify function selection.

A wide range of features and options give maximum flexibility to tailor instrument operation to specific testing requirements. Model 410 operates as a stand-alone benchtop tester or can be used with auxiliary handling equipment and easily fits into sophisticated automatic testing systems.

1.2 SPECIFICATIONS

Admittance Bridge (Constant Voltage)

Range Number		1	2	3	4	5
Range Full Scale *	Cp, Cs	19.999 nF	1.9999 nF	199.99 pF	19.999 pF	1.9999 pF
	Gp, B	125.66 mS	12.566 mS	1.2566 mS	125.66 µS	12.566 µS
	Rs	12.566 Ω	125.66 Ω	1.2566 kΩ	12.566 kΩ	125.66 kΩ
	D, Q	← D to 0.1999, Q to 1999.9 →				
Test Signal Level	HI	← 1.0 V rms →				
	MED	← 100 mV rms →				
	LO	← 10 mV rms →				
Accuracy Multiplier	HI	x 2	← Basic Accuracy →			x 2
	MED	x 2	← Basic Accuracy →			x 2
	LO	x 2	x 2	Basic Accuracy	x 2	x 2

Basic Accuracy (at 23°C)	
	Cp: ±[0.1% of reading + (0.01 + 0.1 G_p/G_{fs})% of full scale]
	Gp: ±[0.1% of reading + (0.01 + 0.1 C_p/C_{fs})% of full scale]
	Cp: ±[0.1 (1 + D)% of reading + 0.01% of full scale]
	D: ±[0.1 (1 + D)% of reading + (0.001 + 0.0001 C_{fs}/C_p)(1 + D)]
	Q: For Q > 5, accuracy of 1/Q = ±(0.1 + 0.01 C_{fs}/C_p)(Q)% of reading
	Cs: For D < 0.2, accuracy same as C_p
	Rs: For D < 0.2, accuracy same as G_p
	B: Accuracy same as C_p
	Note: B and B_{fs} may be substituted for C_p and C_{fs} in accuracy equations.

Impedance Bridge (Constant Current)

Range Number		1	2	3	4	5
Range Full Scale *	Ls, Lp	1.9999 µH	19.999 µH	199.99 µH	1.9999 mH	19.999 mH
	Rs, X	12.566 Ω	125.66 Ω	1.2566 kΩ	12.566 kΩ	125.66 kΩ
	Gp	125.66 mS	12.566 mS	1.2566 mS	125.66 µS	12.566 µS
	D, Q	← D to 0.1999, Q to 1999.9 →				
Test Signal Level	HI	10 mA rms	10 mA rms	1 mA rms	100 µA rms	10 µA rms
	MED	10 mA rms	1 mA rms	100 µA rms	10 µA rms	1 µA rms
	LO	1 mA rms	100 µA rms	10 µA rms	1 µA rms	1 µA rms
Accuracy Multiplier	HI	x 2	← Basic Accuracy →			x 1.5
	MED	x 2	← Basic Accuracy →			x 1.5
	LO	x 2	x 2	Basic Accuracy	x 1.5	x 1.5

Basic Accuracy (at 23°C)	
	Ls: ±[0.2% of reading + (0.01 + 0.2 R_s/R_{fs})% of full scale]
	Rs: ±[0.2% of reading + (0.01 + 0.2 L_s/L_{fs})% of full scale]
	Ls: ±[0.2(1 + D)% of reading + 0.01% of full scale]
	D: ±[0.2(1 + D)% of reading + (0.002 + 0.0001 L_{fs}/L_s)(1 + D)]
	Q: For Q > 5, accuracy of 1/Q = ±(0.2 + 0.01 L_{fs}/L_s)(Q)% of reading
	Lp: For D < 0.2, accuracy same as L_s
	Gp: For D < 0.2, accuracy same as R_s
	X: Accuracy same as L_s
	Note: X and X_{fs} may be substituted for L_s and L_{fs} in accuracy equations.

Temperature Coefficient	One-tenth of rated accuracy, per °C

*D measurements to 1.9999 can be made by programming test mode ØØ14 (see Section 2.5.7).

Table 1-1. Model 41Ø Specifications

Zero Adjustment Ranges (to cancel lead and test fixture effects):

Short-circuit zero -

L	Ø to Ø.2µH
R	Ø to Ø.2Ω

Open-circuit zero -

C	Internally adjustable between Ø to 1pF and Ø to 4pF
G	Ø to 4µS

Measurement Speed: Continuous mode - Approximately one and one-half readings per second.

Single (triggered) mode - Approximately 125ms for 6ØHz line frequency, or 15Øms for 5ØHz line frequency

Displays: Two, 4-1/2 digit, LED, with units symbols

Keyboard: 24-button (21 dual function keys)

Power: 12ØVAC (1ØØ, 22Ø, 24ØVAC optional), 6ØHz (5ØHz optional), 1ØØW

Dimensions: (approximately)
Height - 135mm (5.3 in.)
155mm (6 in.) with feet
Width - 435mm (17 in.)
Depth - 425mm (16.7 in.)

Weight: 14kg (3Ø lb)

Features: External Bias to ±2ØØV on each end of unknown (vs. ground)
Shielded four-terminal unknown connection
Absolute and Percent Deviation
Eleven Programmable Limits
Three Test Voltage/Current Levels
Autoranging

SECTION 2

OPERATION

2.1 FRONT PANEL

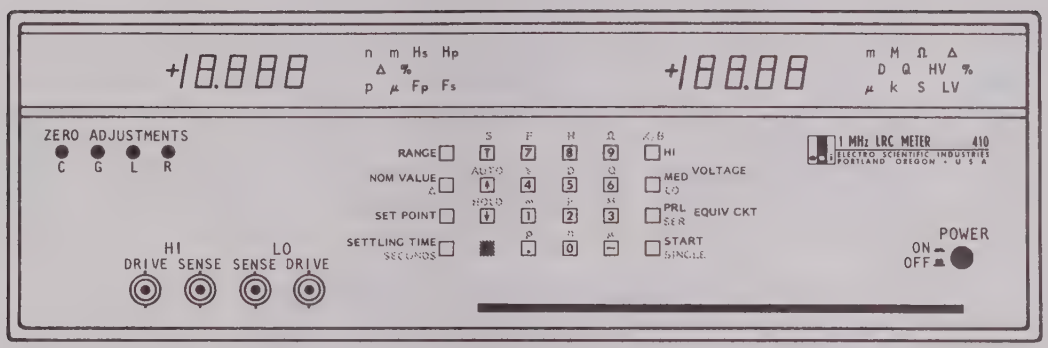


Figure 2-1. Model 410 Front Panel

2.1.1 Keyboard

The keyboard provides all control functions for Model 410. It consists of 24 buttons, 21 of which have two functions. Buttons with two functions have the alternate function represented in red lettering on the front panel. To select an alternate function, the red button must be pushed before the button with the desired function. The function of each button is described below.

./p - Decimal point and pico (10^{-12}) multiplier.
0/n - Zero numeral and nano (10^{-9}) multiplier.
-/μ - Minus sign and micro (10^{-6}) multiplier.
1/m - One numeral and milli (10^{-3}) muliplier.
2/k - Two numeral and kilo (10^{3}) multiplier.
3/M - Three numeral and mega (10^{6}) multiplier.
4/% - Four numeral. % key is used with the limits feature to define and display % deviation.
5/D - Five numeral. D represents dissipation factor measurement function.
6/Q - Six numeral. Q represents quality factor measurement function.
7/F - Seven numeral. F represents farads (the units of capacitance) and capacitance measurement function.
8/H - Eight numeral. H represents henries (the units of inductance) and inductance measurement function.
9/Ω - Nine numeral. Ω represents ohms (the units of resistance) and resistance measurement function.

The above buttons are used to set ranges, desired units of display, and measurement functions. Multipliers allow combinations such as μH (microhenries) and pF (picofarads) to be programmed. The ., - and Ø thru 9 keys are for setting ranges, nominal values, set points and other functions which require input of a specific number.

T/S - The S function provides the units for conductance (siemens) and selects that measurement function. T represents TEST. Pushing this button lights all the numerical displays as a check for burned out segments. It is also used to enter special test mode measurement functions. (See Section 2.5.7.)

↑/AUTO and ↓/HOLD - AUTO and HOLD refer to autoranging and range hold modes. Autoranging is automatically selected when the unit is first turned on. HOLD mode allows rapid checking of many unknowns in the same range. When in the HOLD mode, the ↑ and ↓ shift Model 41Ø up and down ranges. Pushing the ↑ or ↓ button when in AUTO mode puts the instrument in HOLD mode and shifts the range. Red button AUTO returns unit to autoranging mode.

X/B and HI, MED and LO VOLTAGE - X/B changes left reading to reactance (X) when measuring series equivalent circuit, susceptance (B) when measuring parallel equivalent circuit. VOLTAGE button selects the high, medium or low test voltage or current. Voltages and currents are shown in Table 1-1.

PRL/SER EQUIV CKT - Selects parallel or series equivalent circuit measurement modes.

NOM VALUE/Δ - Sets the nominal value for deviation measurement. Δ selects absolute deviation.

SETTLING TIME/SECONDS - Function select and units for programmable settling time. Seconds is also used to terminate test code input.

RANGE - Begins range and function setting procedure, stops measurement, and turns off display. Measurement is resumed by pushing START button. Red button RANGE begins a special procedure for offsetting D readings (in instruments with serial numbers 92ØØØØ and above).

START/SINGLE - Begins measurement after it has been stopped by setting function or range. SINGLE makes one measurement and holds display.

Red Button - Selects alternate function of two-function buttons.

SET POINT - Sets limits bands for limits feature. Advances limits band to next band and prepares instrument to accept numbers and units for that band. Red button SET POINT toggles between indicating band number and normal measurement when set points have been entered.

2.1.2 Displays

The two 4-1/2 digit displays each have a set of units indicators which show the units and functions selected.

p, n, μ, m, k, M - Multiplier prefixes for the basic units programmed, such as pF (picofarads) and μH (microhenries); p=pico, n=nano, μ=micro, m=milli, k=kilo, and M=mega.

Fp, Fs, Hp, Hs, Ω, S, D, Q, - Basic units for functions programmed: Fp=farads, parallel capacitance; Fs=farads, series capacitance; Hp=henries, parallel inductance; Hs=henries, series inductance; Ω=ohms (resistance); S=siemens (conductance); D=dissipation factor; and Q=quality factor. Units for X (reactance) or B (susceptance) are not shown in the left display, but are always the same as for resistance or reactance as shown in the right display.

HV and LV - Indicate high and low voltage or current selection; absence indicates medium voltage or current.

% - Indicates percent deviation display.

Δ - Indicates absolute deviation display.

2.1.3 Other Front Panel Controls

ZERO ADJUSTMENTS - The L, R, C and G zero adjustments on the front panel permit compensation for test fixture series inductance (L) and resistance (R) and shunt capacitance (C) and conductance (G).

UNKNOWN TERMINALS - Four BNC connectors provide shielded four terminal connection to the unknown.

POWER - Turns instrument ON and OFF.

2.2 REAR PANEL

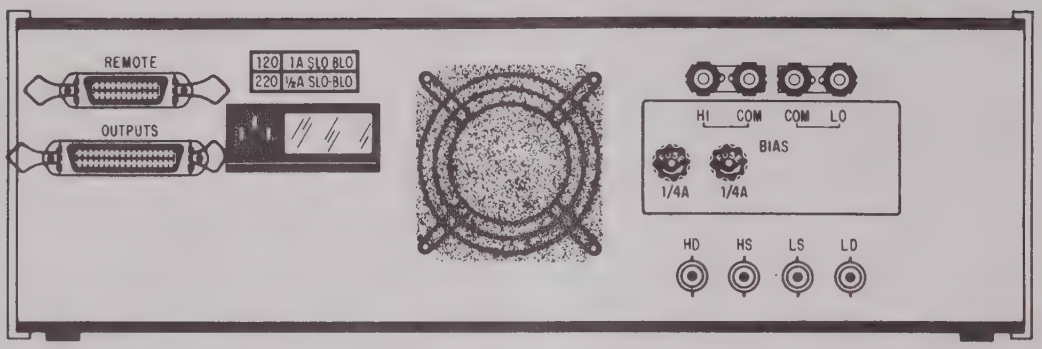


Figure 2-2. Model 410 Rear Panel

Line Cord Connector - The line cord connector meets IEC standards. It is fused and provides for selection of input voltage. It does **not** provide for line frequency changes. Line frequency changes require replacement of internal components. Fuse ratings for 120 and 220VAC input voltages are shown above connector.

REMOTE Connector - A 24-pin connector which allows connection to an IEEE interface bus. Interface option required for operation.

OUTPUTS Connector - A 36-pin connector; outputs dependent on options.

HD, HS, LS, LD Connectors - BNC connectors for making shielded, four-terminal connection to unknown. Duplicates of front panel connectors.

BIAS - Terminals for connection of bias voltages up to ±200V. Bias connections to high and low unknown terminals are separate and independent, and each can be of either polarity. When no bias supply is connected, terminals should be connected together with shorting lugs provided.

Fuses - Protection for bias inputs. Two 1/4A fuses prevent damage to instrument if bias current is not properly limited. See Section 2.5.8.

2.3 MEASUREMENT FUNCTIONS

The basic measurement functions available are shown in Table 2-1. Any left display can be combined with any right display for the same equivalent circuit. Switching from series to parallel, switches 1 to 1, 2 to 2, etc. Deviation and band sorting readings can also be displayed, as discussed in following sections.

	Left Displays (Reactance)			Right Displays (Loss)		
	Symbol	Function	Display	Symbol	Function	Display
Parallel Equiv Ckt	1. L_p	Parallel Inductance	H_p	D	Dissipation Factor	D
	2. C_p	Parallel Capacitance	F_p	Q	Quality Factor	Q
	3. B	Susceptance (Parallel)	None	G	Conductance (Parallel)	S
Series Equiv Ckt	1. L_s	Series Inductance	H_s	D	Dissipation Factor	D
	2. C_s	Series Capacitance	F_s	Q	Quality Factor	Q
	3. X	Reactance (Series)	None	R	Resistance (Series)	Ω

Table 2-1

2.3.1 Test Signal Level

Three selectable test signal levels are available on most ranges and functions. The voltage/current levels are as follows.

Admittance Bridge:

Range Number		1	2	3	4	5
Range Full Scale	Cp, Cs Gp, B Rs D, Q	19.999 nF 125.66 mS 12.566 Ω	1.9999 nF 12.566 mS 125.66 Ω	199.99 pF 1.2566 mS 1.2566 kΩ	19.999 pF 125.66 µS 12.566 kΩ	1.9999 pF 12.566 µS 125.66 kΩ
		D to 0.1999, Q to 1999.9				
Test Signal Level	HI MED LO	1.0 V rms 100 mV rms 10 mV rms				

Impedance Bridge:

Range Number		1	2	3	4	5
Range Full Scale	Ls, Lp	1.9999 µH	19.999 µH	199.99 µH	1.9999 mH	19.999 mH
	Rs, X	12.566 Ω	125.66 Ω	1.2566 kΩ	12.566 kΩ	125.66 kΩ
	Gp	125.66 mS	12.566 mS	1.2566 mS	125.66 µS	12.566 µS
	D, Q	← D to 0.1999, Q to 1999.9 →				
Test Signal Level	HI	10 mA rms	10 mA rms	1 mA rms	100 µA rms	10 µA rms
	MED	10 mA rms	1 mA rms	100 µA rms	10 µA rms	1 µA rms
	LO	1 mA rms	100 µA rms	10 µA rms	1 µA rms	1 µA rms

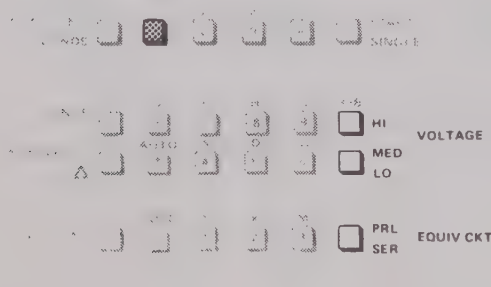
2.3.2 Measurement Display

Results of measurements may be displayed in four different forms: Direct reading, units (absolute) deviation, percent deviation, and band sorting. Direct reading display refers to display of actual quantity as measured in its correct units. Percent and absolute deviation of measured quantities are calculated from a set nominal value. Section 2.5.3 describes this display mode. Band sorting is also calculated from measured quantities. Limits are set by the user and the component is "sorted" into the appropriate limit band based on its measured value. See Section 2.5.4 for operation of band display.

2.3.3 Keyboard Operation - Basic Key Commands

Operating Model 410 is more similar to operating a pocket calculator than a conventional impedance bridge. Functions are labeled on the front panel or on the buttons. Note that most buttons have labels for more than one function. These are called dual function buttons. Functions labeled on the button or in white are selected by pushing the button. Functions labeled in red are selected by pushing the red button first, then the button for the desired function.

Basic measurement selection:



For functions labeled in red, press red key, then desired function.

Select test voltage or current; see specifications for values (Note 1).

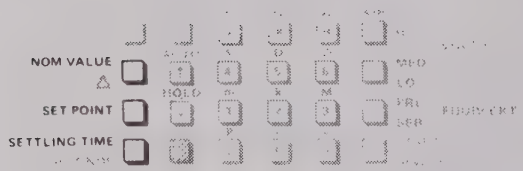
Select parallel or series equivalent circuit (automatically selected with S or Ω for right display).

Select left measurement function:
- F (farads) for capacitance
- H (henries) for inductance
- X/B for reactance (X) when series, susceptance (B) when parallel (Note 2).

Select right measurement function:
- S (siemens) for conductance and parallel equivalent circuit
- Ω (ohms) for resistance and series equivalent circuit
- D for dissipation factor
- Q for quality factor

Select autoranging or range hold, or step up or down one range for each push of key. (For direct range selection, refer to Key Sequence Commands.)

If a nominal value has been entered for either display, readings will be the deviation (Δ) from nominal. Press % for deviation in %, Δ to return to deviation in original units.



Data selectors; press to recall data values (previously entered by Key Sequence Commands) in right display. SET POINT also shows the set point number in the left display, and advances to the next set point with each push of the key. Do not follow with a numerical key unless data value is to be changed.

Start continuous readings, or take one reading and stop.

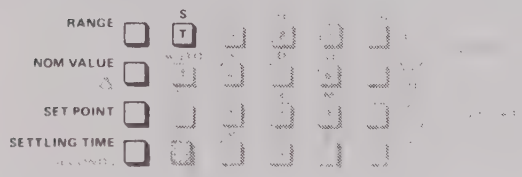
Note 1. Voltage for capacitance or susceptance, current for inductance or reactance, unless reversed by special function command (see 2.5.7).

Note 2. Left display unit and prefix is blank for X or B; use right display unit (Ω or S) and prefix.

2.3.4 Keyboard Operation - Key Sequence Commands

The key sequence commands are discussed in detail in later sections of the manual.

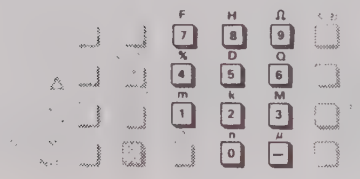
A key sequence command is accepted as valid only if it includes three necessary parts, entered in order, as follows:



1. Data Selector Key

   Identifies data type. Stops readings. Displays value previously stored for NOM VALUE, SET POINT or SETTLING TIME.

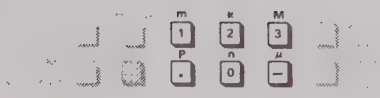
   To save old value, do not follow with a numerical key.



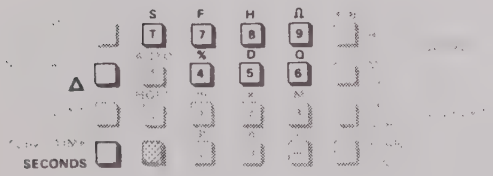
2. Data Value

   Numerical keys including minus sign if applicable. Enter digits from left to right; shown in right display during entry. Treats data as integer values ignoring decimal point and prefix, except for RANGE values. Stores 5 digits if first digit is Ø or 1, otherwise 4 digits. Fills empty places at right with zeros. Ignores excess digits entered.

   To clear keystroke error, push data selector key and enter again.



   Include decimal point and unit prefix for RANGE values.



3. Unit or Function Key

   Terminates string of digits, stores new value in place of old and selects measurement function where applicable.

2.4 INSTRUMENT SETUP

2.4.1 Line Voltage and Frequency Selection

Input voltage selected for Model 410 must match the line voltage available. The line cord connector has provision for changing line voltage, as shown in Figure 2-3. Line voltage only is changed with the line cord connector. Line frequency changes require internal component changes.

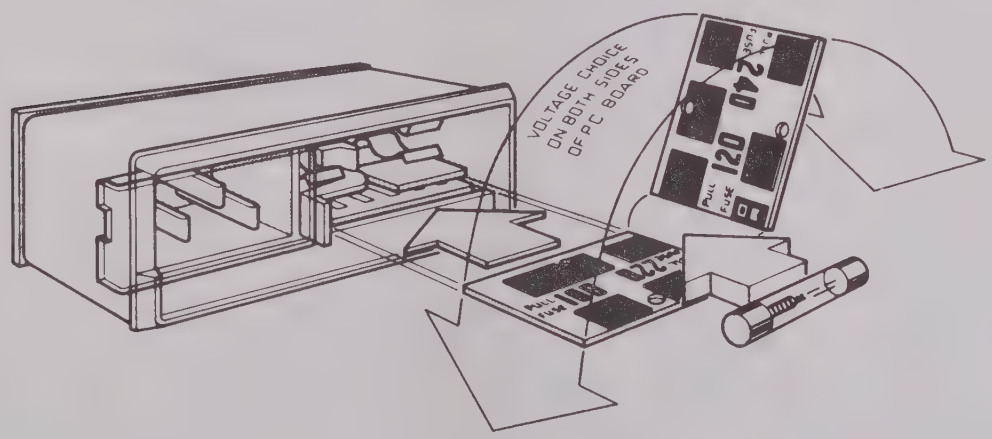
To change line frequency of the Model 410 to 50Hz operation, follow the instructions below.

1. Remove 3.93216MHz crystal Y1 from A/D converter assembly (part number 40689). Replace with 3.2768MHz crystal (part number 24540).

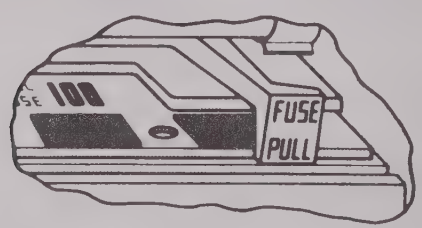
2. Check line voltage setting and change (if necessary) to match available line voltage (see Figure 2-3).

3. Reinstall A/D converter assembly.

NOTE: When removing or inserting PC boards, instrument power must be off. Boards must be inserted with components facing front of instrument.



Operating voltage is shown in module window.



SELECTION OF OPERATING VOLTAGE

1. Open cover door and rotate fuse-pull to left.
2. Select operating voltage by orienting PC board to position desired voltage on top-left side. Push board firmly into module slot.
3. Rotate fuse-pull back into normal position and re-insert fuse in holders, using caution to select correct fuse value.

Figure 2-3. Line Voltage Selection

2.4.2 Connection to Unknown

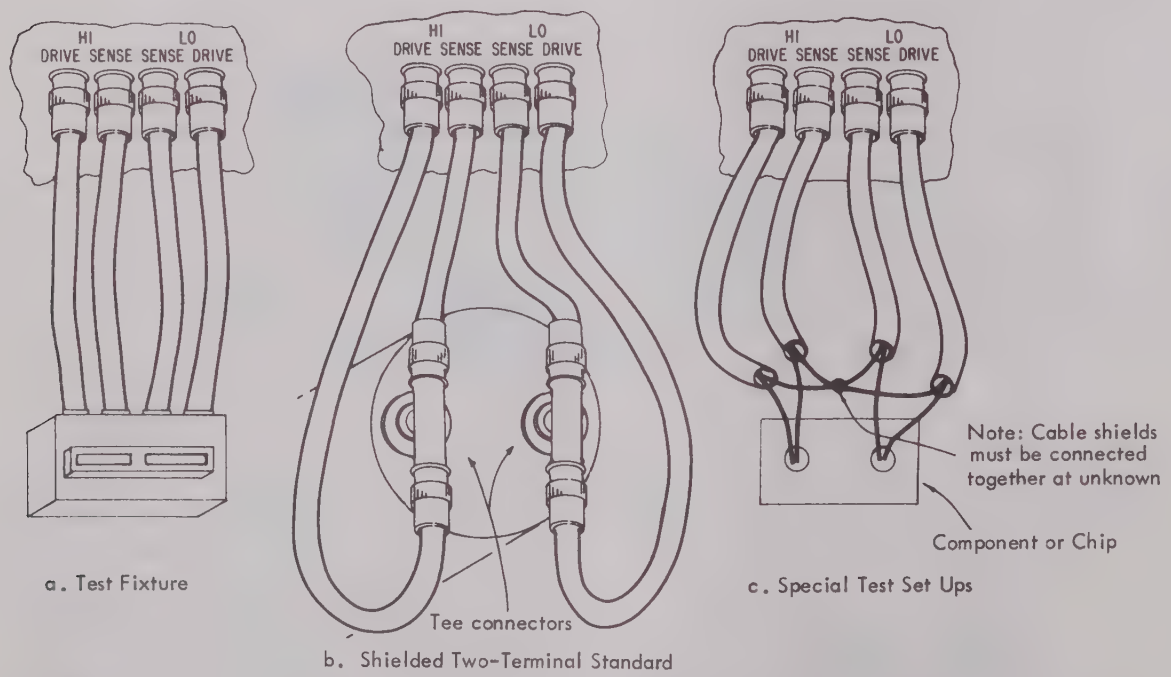
Four shielded cables are used to connect the instrument to the unknown under test. They are labeled HI DRIVE, HI SENSE, LO DRIVE and LO SENSE.

Separate drive and sense connections are especially important at 1MHz to prevent cable inductance, capacitance, and resistance from becoming a part of the measured unknown.

Proper connections are shown in Figure 2-4. Connecting the shields together at the unknown as shown in Figure 2-4c is important. It should always be done in user-built set-ups unless it can be experimentally shown to have a negligible effect at the specific impedance level to be measured.

Always use the specified length and impedance cable. Three-foot lengths of 50Ω coaxial cable, ESI Part No. 19393, are standard. For any other cable length, factory modification of the instrument may be required.

Duplicate unknown connectors are provided on the front and the rear of the instrument. Connect the unknown to one set and be sure nothing is connected to the other set.



a. Test Fixture

b. Shielded Two-Terminal Standard

c. Special Test Set Ups

Figure 2-4. Connections to Unknown

2.4.3 Applying Power

WARNING

INPUT VOLTAGE SELECTOR ON REAR PANEL MUST MATCH POWER LINE VOLTAGE; REFER TO SECTION 2.4.1. CONVERTER CRYSTAL MUST BE CHANGED FOR DIFFERENT LINE FREQUENCY.

To turn instrument ON, press POWER button; its depressed position indicates that it is on.

Initial measurement conditions are parallel capacitance (F_p) and conductance (S) functions, high voltage, autorange, and continuous measurement mode with digital averaging are automatically selected. To turn OFF, press power again, returning button to extended position.

NOTE: The power button can also serve as a reset button.

2.4.4 Lead Compensation

Before taking readings check and adjust (when necessary) the open-circuit C and G and short-circuit L and R zero readings with the unknown leads and fixture or connectors in the configuration in which they are to be used. At 1MHz, measurements of ordinary components can be quite sensitive to the component lead length and its placement in the test fixture. For the open circuit reading, place test clips and shields, if used, at the same spacing as for measurement. For the short-circuit reading, shape a piece of wire to match the lead positions of the component to be measured. (For measurement of calibration standards, follow the open-circuit and short-circuit zero adjustment procedure specified for the standard.)

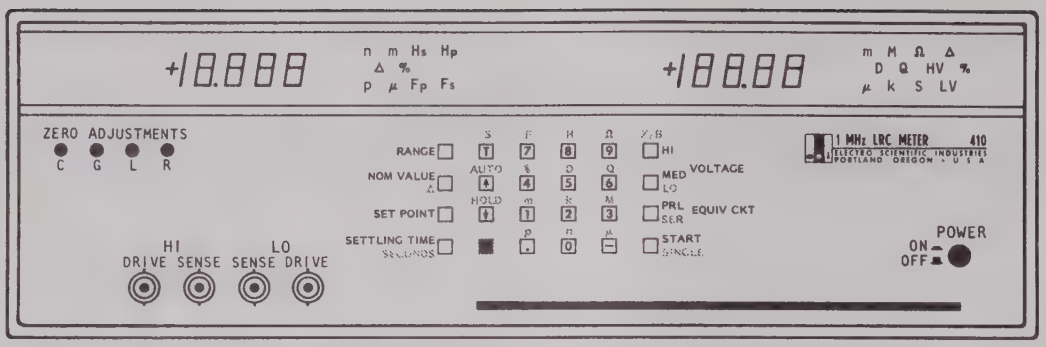


Figure 2-5

The zero adjustments are screwdriver-operated controls behind the labeled holes in the front panel (see Figure 2-5). The step-by-step zero adjustment procedure is as follows:

1. Turn instrument ON; let warm up for at least 1 hour.

2. Set instrument to HI test voltage.

   Push HI VOLTAGE

3. Set to autoranging mode.

   Push AUTO

4. Set to measure parallel capacitance and conductance.

   Push F S

5. With no unknown; adjust front panel C and G zero adjustments for zero ±5 counts in each display.

6. Set to measure series inductance and resistance.

   Push H Ω

7. With short-circuit unknown; adjust front panel L and R zero adjustments for zero ±5 counts in each display.

   NOTE: Always repeat zero adjustment procedure when test leads or fixtures are changed.

2.5 BASIC OPERATION

2.5.1 Function Selection

The Model 410 initially measures Cp and G when power is applied. These measurement functions can be changed at any time by pushing the red button, then the desired function button.

Example: Measure parallel capacitance (Cp) and dissipation factor (D), push red button and D button. Cp and D will be displayed in units of Fp (farads-left display) and D (dissipation factor-right display).

Push [red] [D]

Example: Measure series inductance and resistance push red and H buttons, then push red and Ω buttons. (Ω selects series equivalent circuit).

Push [red] [H] [red] [Ω]

2.5.2 Range Selection

To set a specific range push RANGE button, measurement is stopped and instrument is put in range hold mode; push 0 through 9 buttons corresponding to range value; push red button then buttons for units multiplier and basic unit; push START button to resume measurements.

Example: To set 50pF range, push RANGE button, 5 and 0 buttons, red button, p and F buttons and START button. (199.99pF range is selected.)

Push [RANGE] [5] [0] [red] [p] [F] [START]

Example: Change the range to measure 1nF capacitors: Push RANGE, 1, red, n, F. and START buttons. (1.9999nF range is selected.)

Push [RANGE] [1] [red] [p] [F] [START]

Range can also be changed by pushing ↑ or ↓. These buttons remove the instrument from autoranging mode and move the range once for each button push. Measurements do not stop when these buttons are pushed.

Example: Change range from 199.99pF to 19.999nF. Push ↑ moves to 1.9999nF range, then push ↑ moves to 19.999nF range.

Push [↑] (1.9999nF range) [↑] (19.999nF range)

Example: Down range to the 1nF range. Push ↑ moves down to 1.9999nF range.

Push ↓ (1.9999nF range)

Returning to autorange is accomplished by pushing red button followed by AUTO button.

Example: Set to autoranging mode.

Push ▩ AUTO

2.5.3 Deviation Measurement

Two types of deviation measurement are possible with Model 410: deviation as a percent of nominal or absolute deviation from a nominal in units. Percent deviations may range up to ±100% with the nominal value between 1000 and 10,000 counts on a measurement range. Absolute deviations may range only up to ±full scale (measured value of unknown must not exceed full scale value of measurement range, i.e., the measured value corresponds to less than 19,999 counts of C or L, for example, regardless of its deviation from nominal). Deviation calculations require a small amount of time to complete, so measurement speed is decreased slightly. The additional time required for a measurement is 1ms for absolute deviation, and 5ms for percent deviation.

To measure deviation, a nominal value must first be set. Nominal values are set as a selected number of counts in the desired display and are not a function of range. It is, therefore, important that the instrument be on the desired range. To set a nominal value, push NOM VALUE button, enter desired number of counts and function; decimal point and unit prefix are controlled by measurement range selected and will be ignored if entered.

Example: To set a nominal value of 125pF first set the proper range (199.99pF) then, push NOM VALUE, 1,2,5, red and F buttons.

SET RANGE RANGE 1 2 5 ▩ p F

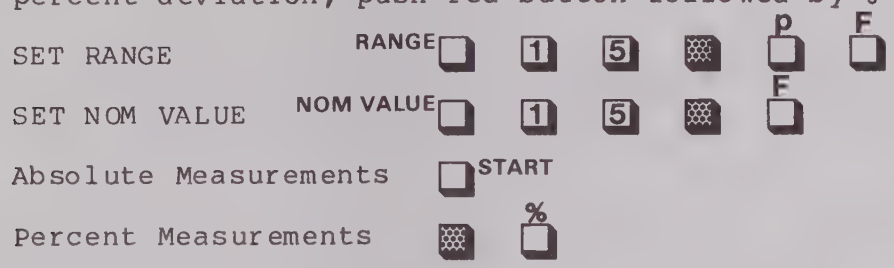
SET NOMINAL VALUE NOM VALUE 1 2 5 ▩ F

NOTE: Absolute deviation requires a nominal for the desired function only; percent deviation requires a nominal for all displayed parameters except D and Q.

The nominal value enters the righthand display as the buttons are pushed. Pushing the function key terminates the nominal value causing it to appear in appropriate display window. Push START button to make absolute deviation measurements.

To change from absolute deviation measurements to percent deviation measurements push red button followed by % button.

Example: To set a nominal of 15pF, push RANGE, 1, 5, red, p and F buttons then push NOM VALUE 1, 5, red and F buttons. To measure absolute deviation push START button. To change to percent deviation, push red button followed by % button.



NOTE: When setting nominal values the decimal point position is fixed by the range selected, care must be taken to enter the correct sequence of numbers to achieve the desired nominal. Also note that the first digit on each display is a ±1 display only and cannot show a zero digit input. For example, to set a nominal D value of Ø.ØØ1, press digits Ø, Ø, Ø, 1. When the first Ø is pressed, the display will not show it since the digit is only capable of displaying a +, - or 1. After pressing the second Ø, the display will echo the digits entered.

Nominal values can be examined by pushing the NOM VALUE button. The current nominal settings will appear in appropriate display windows.

To temporarily exit from deviation mode, push SET POINT then START. To return to deviation measurement with the same nominals, push NOM VALUE then START. If the unit had been measuring percent deviation before temporarily exiting, red button % must be pushed to return to percent deviation measurements.

After exiting deviation measurement mode by pushing SET POINT then START, it is possible to enter limits mode operation by entering desired limits (see Section 2.5.4). The nominals entered for deviation measurement are then used as nominals for % limits operation.

The unit is removed from deviation mode by programming nominal values of Ø for both reactive and loss functions.

2.5.4 Limits Operation

Limits mode operation allows unknowns to be sorted into tolerance bands based on set point limits programmed by the operator. There are eleven set point limits numbered 1 through 11, which give ten bands, numbered Ø through 9, plus a secondary parameter band numbered 1Ø. Set point limits can be arranged in two methods: ten bands for reactance of the unknown and one maximum limit for its loss; or ten bands for loss component of the unknown and one maximum limit for its reactance. The choice between these two arrangements is made when the first set point limit (number 1) is programmed. If a reactance function is programmed for set point limit one, the ten bands will be allotted for reactance component of unknowns and number 11 limit for loss component. Similarly, if a resistive function is programmed for set point limit one, the ten bands are used for loss and number 11 for reactance components. For example, the first arrangement allows capacitors to be sorted into ten tolerance bands with a single maximum limit on D value. The second arrangement allows resistors to be sorted into ten bands with a maximum limit on their inductance. Calculation time for limits operation adds 7ms to overall measurement time.

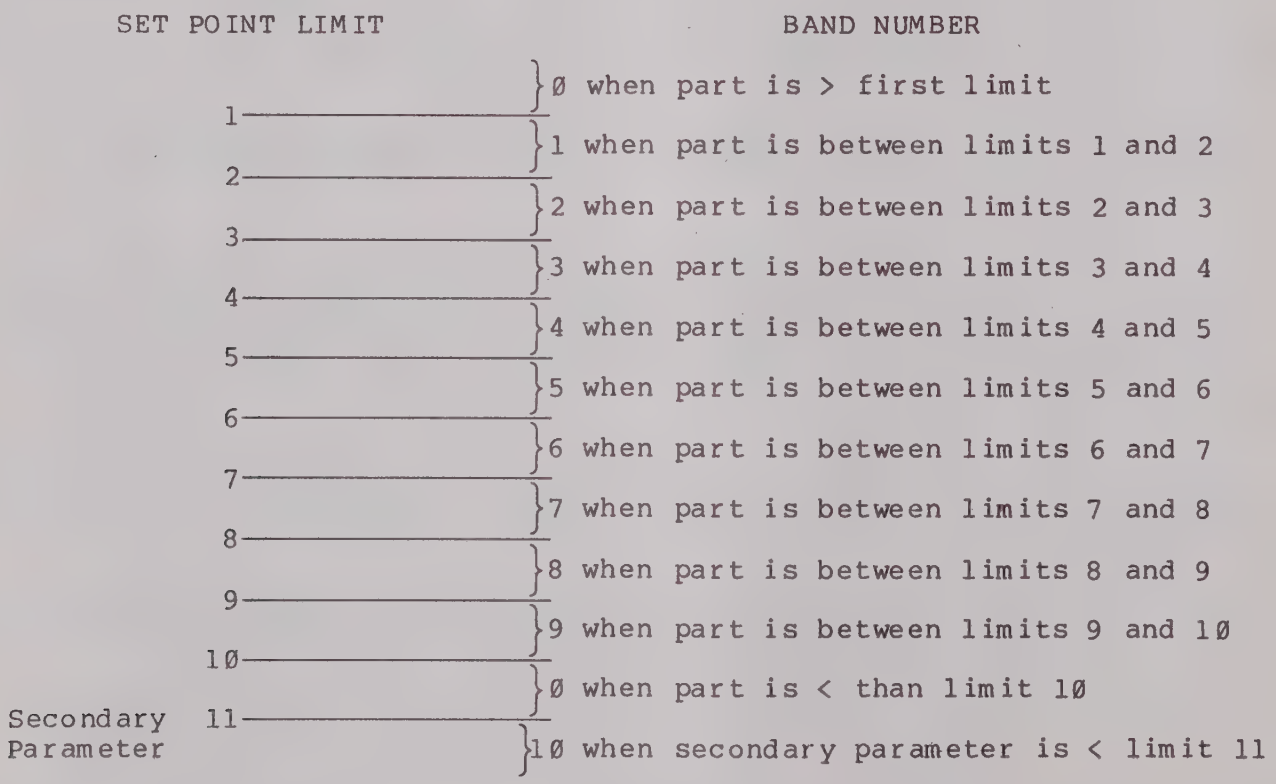

SET POINT LIMIT
BAND NUMBER
Ø when part is > first limit
1
1 when part is between limits 1 and 2
2
2 when part is between limits 2 and 3
3
3 when part is between limits 3 and 4
4
4 when part is between limits 4 and 5
5
5 when part is between limits 5 and 6
6
6 when part is between limits 6 and 7
7
7 when part is between limits 7 and 8
8
8 when part is between limits 8 and 9
9
9 when part is between limits 9 and 1Ø
1Ø
Ø when part is < than limit 1Ø
Secondary Parameter
11
1Ø when secondary parameter is < limit 11

Figure 2-6.

The limits may be set in units or percent. They must be programmed in ascending order with each limit greater in value than the preceding. A limit equal to or less than the previous limit will not be accepted and will cause display blinking. When the instrument is turned on it initializes to the first limit (number 1). Each push of the set point button advances the limit number. The following procedures outline the process involved in setting and operating limits.

1. Set Model 410 to desired range. Push SET POINT button. The left display will show the number of the set point limit being programmed (number 1). (Set point limit number 1 must always have a value entered.)

2. Enter numerals for desired limit (numerals will appear in right display). Entries are in counts; decimal point and prefix entries will be ignored. End with red button then function for desired limit. The function entered at the first step chooses between the two arrangements for the set point limits (ten limits for reactance and one for loss, or ten limits for loss and one for reactance). Entries for the remaining set point limits (except limit 11) must be of the same function.

3. Push SET POINT again and repeat step 2 to program next set point limit. Repeat until all desired limits are set. At least two limits must be set.

4. To program number 11 limit, enter numerals and function as in other set point limits. Function must be of opposite type (reactance or loss) than the function for the other limits. When the function is entered, number 11 limit is set.

5. Push red button SET POINT then START button to begin measurement. Display will show band number. To show measured value of unknown, push red button SET POINT. Red button SET POINT toggles between showing measured value and band number.

To set percent limits:

For percent limits operation, nominal values must first be set.

1. Set Model 410 to desired range. Enter nominal values for reactance and loss components as in deviation measurement description, Section 2.5.3. One will be used for nominal on the ten bands, the other will be used for the maximum limit nominal.

2. Push red button and % (display will blank). Push SET POINT button. The left display will show the number of the limit being programmed.

3. Enter numerals for the desired percent limit. Numerals will appear in right display. The decimal point is fixed, as shown in the display. Leading zeros must be entered, but trailing zeros may be left off. For example to enter 10.00% limit, digits 0, 1 must be pushed; the 3 following zeros are optional.

4. Push red button and function. When function button is pushed, right display will be replaced by a number equal to the nominal deviated by % limit entered. The number showing may have a one count error due to round off in the calculation. The function entered for limit 1 is used for limits 1 through 10.

5. Push SET POINT button and repeat steps 3 and 4 for the remaining set point limits. At least two limits must be set.

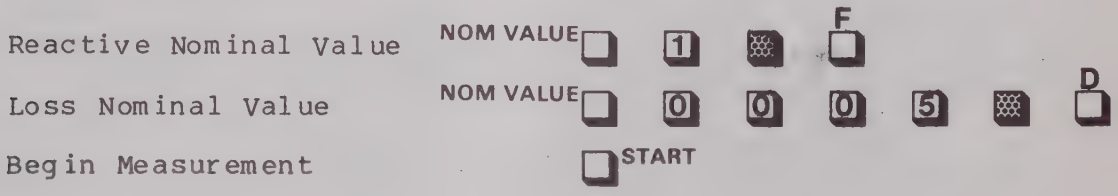
6. To program number 11 limit, push SET POINT, digit 0, then function desired. Instrument will program 11 to nominal entered for that function in step 1 above. This set point limit is a maximum limit, not percent.

7. When all set point limits are set, push red button SET POINT then START to begin measurement.

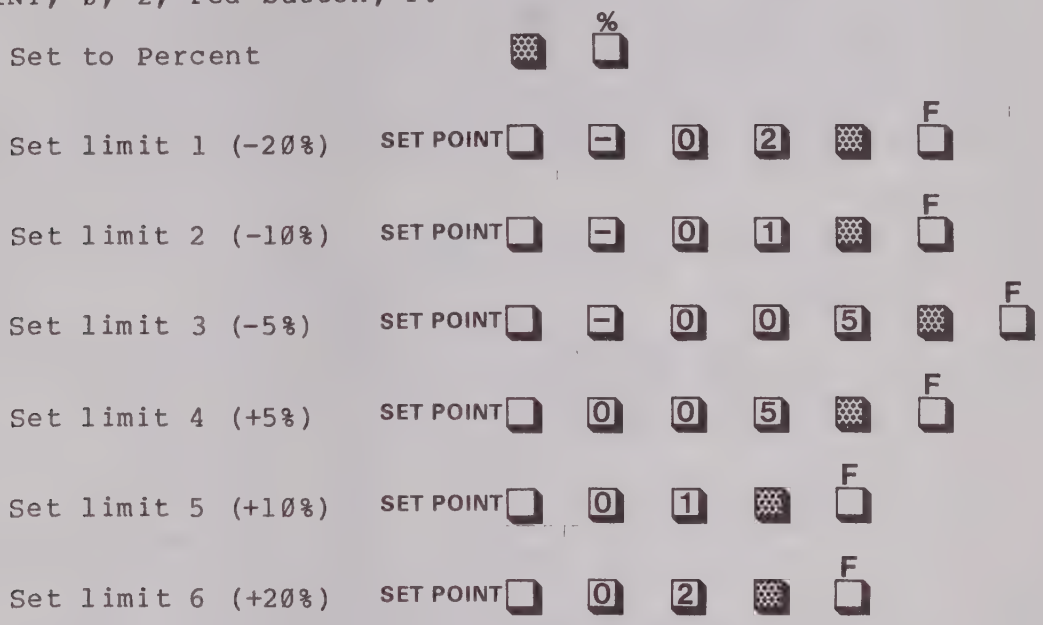
When operating, the display shows the proper band number for the unknown component. If the reactance is being sorted into ten limits, band number appears in the left display. Measured value of the component flashes on and off alternately with the band number. Band numbers shown indicate the component is greater than the set point limit of the same number and less than the next higher set point limit. Band 0 indicates the component is either larger than the highest limit or smaller than the smallest limit. Band 10 indicates component has exceeded limit number 11.

Example: Sort 100pF capacitors at HI test signal into ±5%, ±10%, ±20% bands with maximum D of 0.005. Begin by setting proper voltage and range: push HI VOLTAGE button then push RANGE, 1, 0, 0, red, p, and F buttons.

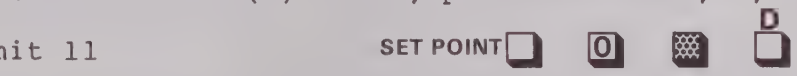
Next set nominal values: push NOM VALUE, 1, red button, F (trailing zeros may be left off, decimal is controlled by range selected). Push NOM VALUE, 0, 0, 0, 5, red button, D. Push START button.



Now set the limits, in percent. Push red button %. Push SET POINT -, Ø, 2, red button, F; SET POINT -, Ø, 1, red button, F; SET POINT -, Ø, Ø, 5, red button, F; SET POINT, Ø, Ø, 5, red button, F; SET POINT, Ø, 1, red button, F; SET POINT, Ø, 2, red button, F.



To set the loss (D) limit, push SET POINT, Ø, red button, D.



Push red button SET POINT then START button to begin measurement. Display will show band number. To show measured value of unknown, push red button SET POINT. Red button SET POINT toggles between measured value and band number.

To examine set point limits, push SET POINT repeatedly to display limits in ascending order.

For parts that do not fall within the acceptable limits it is sometimes desirable to separate the high rejects from the low rejects. This is accomplished by programming set point limit 1 to -15 (this represents -15,ØØØ counts when measuring in absolute limits mode and -15Ø.ØØ% in percent limits mode) and set point limit 2 for the lowest limit.

Band 1 now represents low rejects with band Ø representing high rejects.

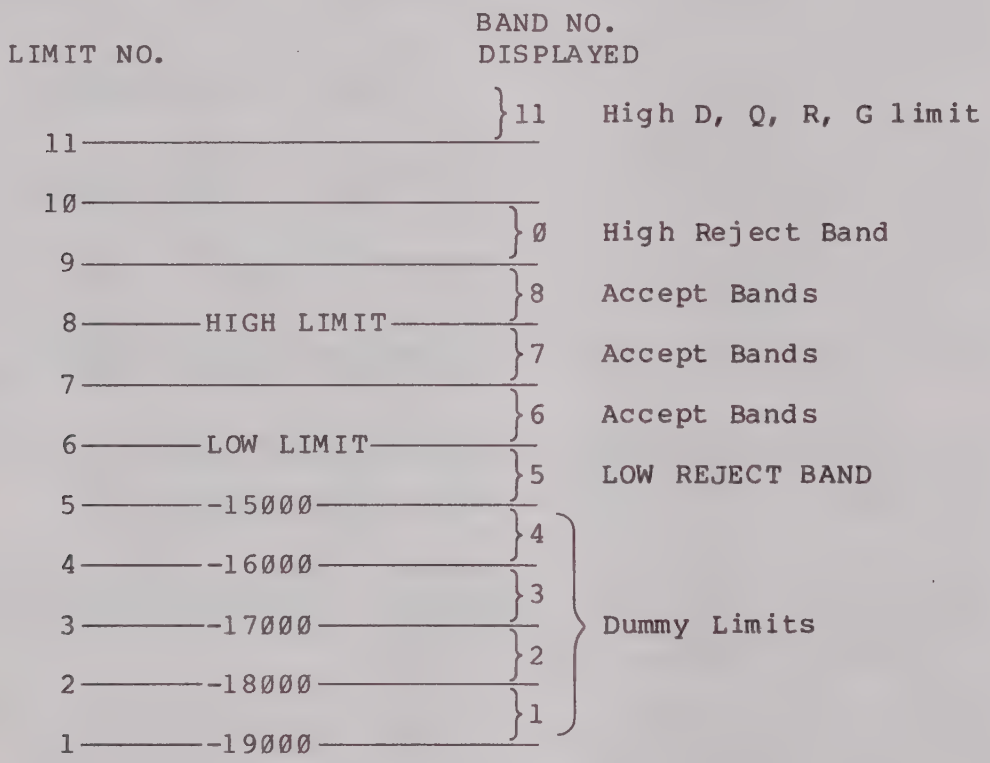
Sometimes it is not desirable to program all set point limits but only a few. (For example, a parts handler used in a 3-band sorting operation may require that set points 6, 7 and 8 be used rather than

1, 2 or 3.) Intermediate bands can be skipped as long as set point No. 1 has a number entered and the limits are set as a group. To insure the low reject band is still 1 less than the lowest limit set:

1. Program set point limit 1 with a value that is more negative than the low limit value.

2. Program all ascending limits with an increasingly positive value until the low limit set point is reached.

Example:



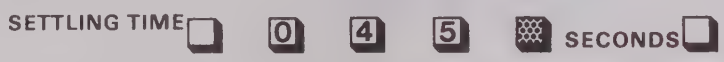
To temporarily exit from limits mode into measuring the functions set in limits mode, push red button SET POINT. Again pushing red button SET POINT toggles back into limits mode. Band sorting information is continuously provided to external handlers, even when the operator toggles out of limits mode, if a handler interface kit is installed.

To completely exit from limits mode, set point limit 1 must be set to zero. If percent limits are set, the instrument must be programmed to absolute limits (by pushing red button, Δ) before setting limit 1 to zero. To return to limits operation re-enter desired set point limits. When power is turned off, all set point limits and nominal values are lost.

2.5.5 Settling Time

Settling time may be programmed by the operator from the front panel or remotely with the GPIB option. If no settling time is set, the unit assumes a standard settling time of Ø.ØZ second which is optimum for normal use. Settling times less than standard may inhibit autoranging. To program settling time, push SETTLING TIME button, enter desired settling time in seconds, then push red and SECONDS buttons. Settling time entered may be between Ø.Ø1 second and 1.2Ø seconds to nearest Ø.Ø1 second.

Example: To set settling time of 45Ø milliseconds, push SETTLING TIME, Ø, 4, 5 red, and SECONDS buttons.



NOTE: The display will show .45 seconds as settling time. The unit will truncate it at the Ø.Ø1 second digit.

2.5.6 Measurement Speed

Model 41Ø offers a choice of two measurement modes. They are measurements with digital averaging which reduces noise effects and measurements without digital averaging to increase measurement speed (see Figure 2-7).

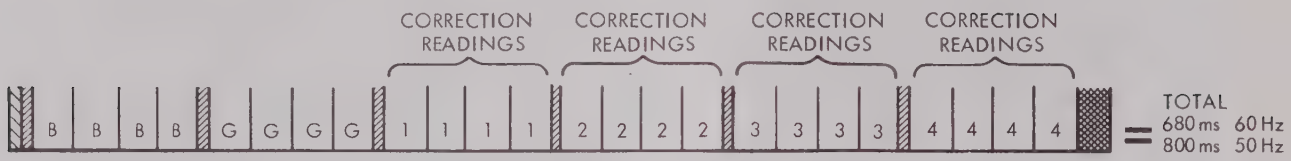
Continuous measurements are normally made with digital averaging. This provides the lowest noise and slowest measurement speed, because six measurements (two zero correction measurements; two phase correction measurements and two main measurements) are required for each front panel display. Each of these six measurements is the average of four individual readings, a total of 24 measurements for each reading. For faster continuous measurements, the averaging can be eliminated by programming special test code ØØ1Ø (see Section 2.5.7 for an explanation of special test code operation).

Single measurements are normally made without digital averaging. They have the fastest measurement speed. Each measurement cycle consists of two main measurements and one correction measurement. (Four correction values are used to calculate displayed readings, but only one of the four values is updated each measurement cycle.)

Slower but quieter single cycle measurements with digital averaging are made by programming special test code ØØ12 (see Section 2.5.7).

NORMAL MEASUREMENT MODE

Continuous Measurement Mode with digital averaging.


CORRECTION READINGS
CORRECTION READINGS
CORRECTION READINGS
CORRECTION READINGS
B B B B G G G G 1 1 1 1 2 2 2 2 3 3 3 3 4 4 4 4
TOTAL
680 ms 60 Hz
800 ms 50 Hz

Single Cycle Measurement Mode without digital averaging.

SPECIAL TEST MODES

Continuous Measurement Mode without digital averaging (test mode ØØ1Ø).

Single Cycle Measurement Mode with digital averaging (test mode ØØ12).

Settling Time - 2Øms normal (can be programmed between Ø.Ø1 and 1.2Ø seconds).

Switching Time - 5ms typical

Conversion Time - 25ms typical for 6ØHz line frequency
3Øms typical for 5ØHz line frequency

Final Calculation Time - 3Øms typical

Figure 2-7. Measurement Speed

The total measurement time of the Model 410 is the sum of:

1. Total Settling time
2. Total Switching time
3. Total Digital Conversion time
4. Final Calculation time
5. Special function execution time (options)
6. GPIB or TTY data transfer period (options)

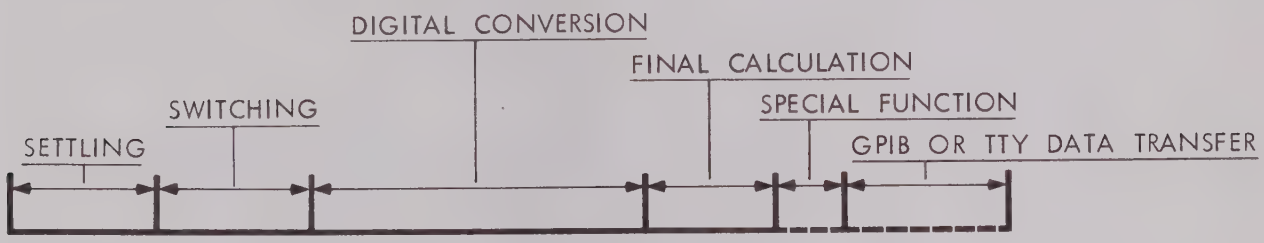
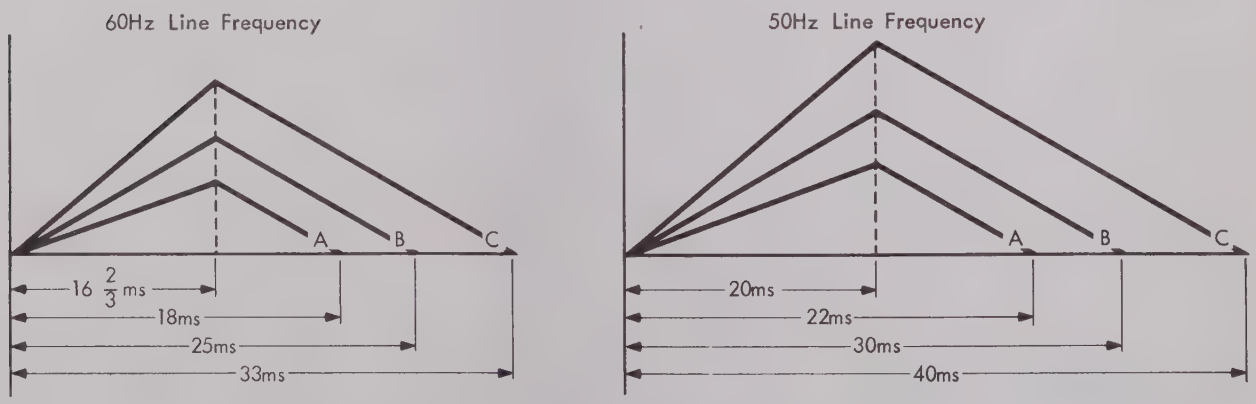


Figure 2-8

1. Settling time is the time required for the analog voltage representing the unknown to settle to the desired accuracy. Settling time is programmable over the range of 10ms to 1.2s (see Section 2.5.5).

2. Switching Time is the time required to select a new measurement function and for the selected analog signals to settle to the desired accuracy.

3. Digital conversion times of each measurement depend on the measured value, the line freqency and the operating mode.



A = Full Scale Value B = Zero Value C = Shorted Capacitor Condition

Figure 2-9.

Measurement conversion times are shortest for positive full-scale values and longest for zero or negative values. Conversion time, therefore, depends on what percent of full-scale the unknown represents. The greater part of full-scale, the faster the conversion time.

4. Final calculation time is 20ms. This is the time required to calculate the displayed values.

5. Special function execution time. Additional time is required to execute special functions.

Absolute deviation mode:	1ms
Percent deviation:	5ms
Limits mode:	7ms
Relay closure of handler interface:	1ms
TTL outputs of handler interface:	included within 7ms of limits mode

6. GPIB or TTY data transfer periods. Time is required to output ASCII characters. This time is dependent on the bus system being used and the length of the command and data output character string. Transfer of data on the GPIB is dependent on slowest device connected to the bus.

2.5.7 Test Mode Functions

Test Mode is a special programming sequence which provides several additional operating functions. Table 2-2 lists these functions and their programming codes. Test Mode functions may be programmed with the interface options just as all other functions. (The keyboard unlock function is not programmable from the front panel, only remotely.)

The procedure for programming test mode functions is as follows:

1. Press test button (T) on the front panel keyboard. The display will show all segments: 1.8.8.8.8.

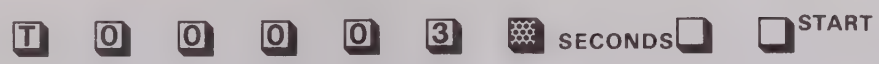
2. Push the 0 button. The displays will be blank except for decimal points.

3. Enter the desired four-digit code.

4. Press red button, SECONDS button, START button (in this exact sequence).

The instrument will now be operating in the selected mode.

Example: The key sequence for test code 0003 is T,0,0,0,0,3, red button, SECONDS, START.



CODE	FUNCTION
0000	Unlock front panel (remotely programmable only; keyboard is ignored when locked)
0001	Lock front panel in remote mode
0002	Clear constant current capacitance and constant voltage inductance mode (default)
0003	Set constant current capacitance and constant voltage inductance mode
0004	Lock front panel in continuous measurement mode
0005	Not used
0006	Display zero correction values – DAC zero display <100 counts!
0007	Display phase correction values
0008	Clear talk only mode (default)
0009	Set talk only mode (printer)
0010	Clear averaging mode
0011	Restore normal averaging mode (default)
0012	Allow averaging on single cycle measurements
0013	Restore normal D mode
0014	Set expanded D measurement mode
0015	
0016	Auto zero for only rng used – will not carry over properly to otherwise!

Table 2-2. Test Mode Functions and Codes

Codes 0000 and 0001 control the front panel lockout feature. This feature allows the controls to be set for the desired measurement operation and then the front panel locked to protect against accidentally changing the settings. After the front panel is locked a remote start signal is required to begin measurement. Since the front panel is inoperative when locked, it is not possible to unlock the front panel using the keyboard. Three methods can be used to unlock the

front panel: turn the unit off then back on, remotely program an unlock command, or close a switch connected to the TTY option front panel unlock feature.

Codes 0002 and 0003 control a special measurement mode. In this mode capacitance is calculated from measured inductance and inductance is calculated from measured capacitance. Capacitors are measured with constant current and inductors with constant voltage. (Normal measurements are made with constant voltage for capacitance, constant current for inductance). Note that since large capacitor values are greatly affected by lead inductance, it is especially important to cancel the inductive effects of test fixtures and leads as described in front panel L and R zero adjustment section. Since functions in this test mode are calculated, values must be between approximately 1300 and 20,000 counts on a range. In addition to over-range indicated, values below approximately 1300 counts cause under-range overload indications. Autoranging feature may not operate in this mode in all cases. This mode is useful for measuring high loss series capacitances whose dissipation factor is too large to allow calculation of C_S and R_S on the normal function.

Code 0004 programs continuous measurement mode and locks the front panel. The panel may be unlocked by the methods listed for codes 0000 and 0001.

Codes 0006 and 0007 display the two zero corrections and the two phase corrections which are used in the calculation of the final measured value.

Codes 0008 and 0009 control the TALK only mode, designed for operation with a printer, is controlled by codes 0008 and 0009. Selection of test 0009 causes Model 410 to output its data to IEEE Bus or TTY indicating when material is finished. Test 0008 clears this mode.

Codes 0010, 0011 and 0012 control measurement averaging operation. Model 410 performs two types of measurement cycles: continuous and single cycle. Normal continuous measurements consist of four measurements averaged then displayed. Single cycle normally consists of a single measurement. Code 0012 changes single cycle measurements so that four readings are taken and averaged for display each time measurement is initiated. Code 0010 allows continuous measurements without any averaging. Normal averaged continuous and non-averaged single cycle measurement are restored by code 0011.

Codes 0013 and 0014 select extended dissipation factor (D) measurements. Code 0014 allows measurement of components with D's greater than 0.2 (20%) and also increases measurement speed. Measured full scale is 1.9999 when this mode is selected. Code 0013 restores normal D operation.

Extended D was the initial starting D measurement mode in instruments with serial numbers 834009 and smaller.

2.5.8 Measurements with DC Bias

Two pairs of bias input terminals on the rear panel allow application of separate, independent bias voltages to the high and the low ends of the unknown, relative to the common connection (analog ground). Each bias can be of either polarity, and can have a maximum voltage of ±200V (400V maximum across unknown with opposite polarities). Bias supplies should be current limited to 100mA or less, continuous.

The separate bias connections permit measurement on three-terminal devices, such as transistors, with specified voltages applied to both measurement terminals.

For application of a single bias voltage, or bias current, either bias input may be used. The other bias input may be used for current measurement or kept shorted to serve as a current return path.

WARNING

ELECTRICAL SHOCK HAZARD EXISTS WHEN BIAS SUPPLIES ARE CONNECTED TO THIS INSTRUMENT. WHEN EXTERNAL BIAS SUPPLIES ARE ATTACHED, THE BIAS VOLTAGES ARE PRESENT ON BOTH FRONT AND REAR PANEL BNC CONNECTORS. USE ONLY BIAS VOLTAGES UP TO ±200VDC WITH EACH BIAS SUPPLY CURRENT LIMITED AT 100mA. DO NOT TOUCH, CONNECT OR DISCONNECT THE UNKNOWN OR BNC CABLES WHILE BIAS VOLTAGES ARE APPLIED.

2.5.9 Resistor Measurements

Resistors should be measured in combination with inductance or reactance functions rather than capacitance function. When in capacitance mode, a resistor is interpreted as a high loss capacitor and may cause the display to blink. Switching to inductance or reactance measurement allows proper measurement.

2.5.10 D Accuracy vs C Reading

Model 410 accuracy specifications are written to allow for small variations in phase shift. These phase shifts are a function of the major reading and are present on all ranges. The Calibration Procedure (Section 4.1) adjusts D readings to be most accurate at a capacitance reading of 10,000 counts. This provides the "best line fit" accuracy specification.

For applications where D accuracy at a particular value is especially important, a D correction can be determined by measuring a capacitor of known D at the same value as the capacitors to be tested. The difference between the measured value of D and the known value is the correction value (in counts). This correction value can be added to or subtracted from any C reading at that capacitance value using the following procedure:

1. Push red button then RANGE button. The right display will respond with all zeros or the last value entered.

2. Enter numerals for the desired correction value (in counts).

3. When the correction value is entered push red, SECONDS and START buttons. D readings will now be the corrected value.

Correcting the D value also causes Q readings to be corrected. This happens because Q is calculated as 1/D reading. All other measurement functions are unaffected.

Example:

If a standard capacitor has a known D value of 0.0003 but its measured D is 0.0020, the correction value is -0.0017. To enter the correction value push red, RANGE, -, 0, 0, 0, 1, 7, red, SECONDS and START buttons.

NOTE: Correction values are made for a particular value and must be removed or changed when measuring other values. The correction value is removed by pushing red, RANGE 0, red, SECONDS and START buttons.

2.6 OPTIONS OPERATION

Options for Model 410 are plug-in circuit assemblies. That can be plugged into one of two available sites. (Options can be plugged into only the site assigned.) When plugging in or removing options, power should be off to avoid damage to circuitry.

SECTION 3
CIRCUIT DESCRIPTIONS

3.1 INTRODUCTION

The Model 410 LRC Meter consists of three major sections. The first is the analog system (located on the left half of the instrument) which produces dc voltages proportional to the reactive and resistive part of the unknown being measured. The second (located on the right half of the instrument) is the digital section which consists of the following circuit assemblies:

1. The A/D converter which converts the dc voltages produced by the analog system into digital information.

2. The central processing unit which contains the microprocessor, memories, clock, bus drivers and other necessary components. The CPU accepts the digital information from the A/D converter and performs the calculations necessary to derive the desired information about the unknown. The CPU also monitors the keyboard for input instructions and provides the signals for control of functions and ranges to all other circuit assemblies.

3. Plug-in options such as IEEE bus module or contact closure module for band sort indication.

The third major section is the operator interface consisting of the keyboard for input and the display circuit assembly for visual output of measured information.

A power supply located in the right rear of the instrument provides the necessary dc operating voltages.

Refer to Figures 3-4 and 3-5 for simplified circuit diagrams.

3.2 THE ANALOG SYSTEM

The analog system is comprised of two sections - a bridge balancing section and a signal measurement section. The function of the bridge balancing circuitry is to provide a regulated reference voltage and a variable voltage that is proportional to the unknown. During capacitance measurements a regulated test voltage is applied to the unknown (Figure 3-1) while the voltage across the standard resistor is varied to produce a voltage that is proportional to the unknown admittance (Y). (This voltage is varaed until a null is produced at the junction of the unknown and standard resistor, see Figure 3-2.) For inductance measurements the voltage across the standard resistor is regulated to maintain a constant current through the unknown.

(Figure 3-3) while the voltage across the unknown varies in proportion to the unknown impedance (Z). Each voltage is sensed and amplified by gains of 1,10 and 100 as required for the range and measurement voltage level chosen.

The signal measurement section applies the variable signal to signal amplifier VSØ. The regulated reference signal is sent to phase splitting circuitry having one output VRØ matched in phase with amplifier VSØ and another output VR9Ø that is phase shifted 90° from VSØ. These signals are filtered and applied to phase rectifiers. The variable signal phase rectifier produces a dc output proportional to conductance (G) and resistance (R) when the reference is VRØ and proportional to susceptance (B) or reactance (X) when the phase reference is VR9Ø. The reference signal phase rectifier output is used to regulate the bridge test voltage or current.

The following sections contain brief descriptions of operation for each type of assembly located in the analog portion of the instrument. Refer to the simplified block diagram Figure 3-5. For additional detail see the schematic diagrams in Section 5 of this manual.

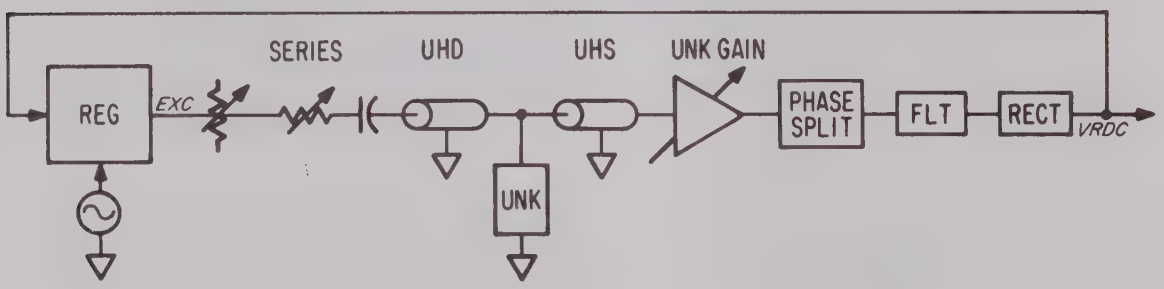


Figure 3-1. Constant-Voltage Regulation

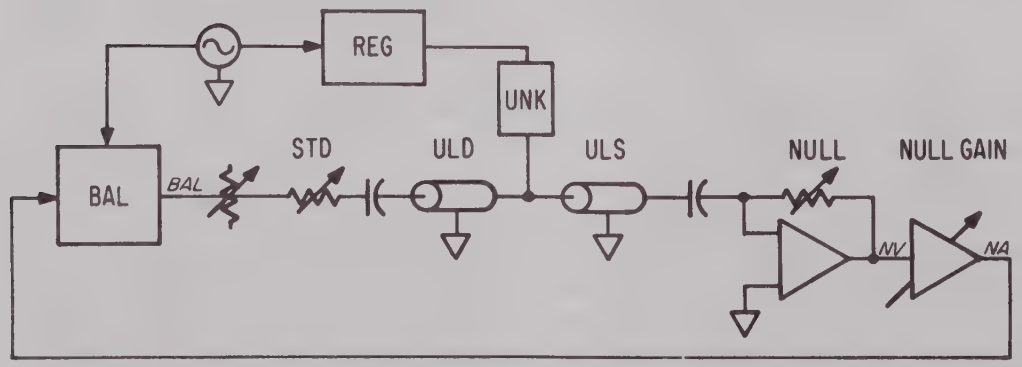


Figure 3-2. Null Balancing

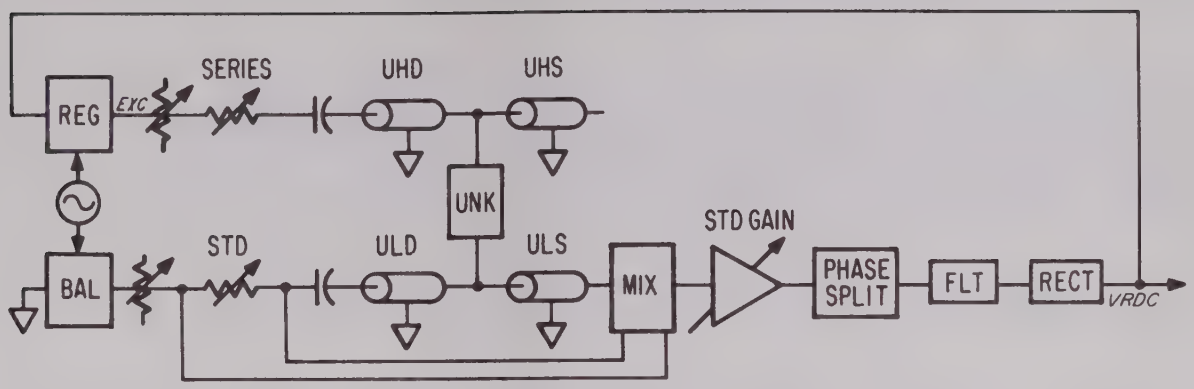


Figure 3-3. Constant-Current Regulation

3.2.1 Excitation Assembly ESI Part Number 40666

Located on this assembly is a 1MHz crystal-controlled sinusoidal oscillator. This 1MHz signal of approximately 1VRMS is used as a source for both the excitation and balance signals. The 1MHz signal is applied to a level regulator controlled by the dc reference voltage (VRDC) to produce a signal which is amplified and applied to the unknown through the high assembly.

3.2.2 High Assembly ESI Part Number 41322

The High Assembly contains signal attenuators required to produce the various excitation levels. It also contains series resistors required for stability when applying constant current to the unknown. The regulated excitation is applied to the unknown from this board (UHD) and is remotely sensed (UHS) by a buffer amplifier. The L and R front panel trimmer signals are injected into the signal path on this assembly before the signal passes to the unknown gain assembly.

3.2.3 Gain Assembly ESI Part Number 41379

This assembly is used three places in Model 410: Unknown Gain, Standard Gain and Null Gain. On this circuit assembly there are two noninverting amplifiers each with gain switchable between x1 and x10. Depending upon range and measurement voltage level selected, this board will amplify the signal by a gain of 1, 10 or 100.

3.2.4 Null Assembly ESI Part Number 41360

The Null Assembly remotely senses any error signal (deviation from null) at the low end of the unknown (ULS). This null amplifier is an inverting amplifier with switched feedback resistors tracking the standard (range) resistors. The amplified error signal is sent to the balance assembly and is also mixed with the standard signal to produce an approximately correct measurement until the error is balanced and eliminated. The C and G front panel trim signals are injected into the signal path on this assembly.

3.2.5 Balance Assembly ESI Part Number 40663

This assembly produces the variable signal across the standard (range) resistor. This signal is used to balance the bridge; i.e., to cancel the error signal at the low end of the unknown. This is done when the error signal from the null gain assembly is fed to two ac integrator channels, one with a reference in phase with the oscillator; the other 90° out of phase with the oscillator. The outputs of these channels are mixed, amplified and sent to the standard assembly as the BAL signal. The ac integrating action works continuously to supply whatever output is required to drive its input to a null.

3.2.6 Standard Assembly ESI Part Number 41323

The Standard Assembly contains standard (range) resistors and attenuators which are selected according to the range and measurement voltage level chosen. The BAL signal is applied to the standard resistors and is used to drive the null error signal to zero. The SHS and SLS signals from the high and low end of the standard resistor are sent to the null assembly to be mixed to produce the measured standard voltage (SV).

3.2.7 Phase Splitter Assembly ESI Part Number 41277

On the Phase Splitter Assembly are two signal select relays and three amplifiers. Signal selects relays K1 and K2 steer the variable and reference input signals to the proper amplifier. The variable (measured) signal is applied to amplifier VSØ. The regulated reference signal is applied to both the VRØ amplifier whose output is matched in phase with the VSØ and the VR9Ø amplifier whose output is phase shiften 9Ø° from the VSØ amplifier. (The VRØ and VR9Ø amplifiers are trimmable in phase and magnitude.) These signals are sent to the Measurement Selector assembly for further processing.

3.2.8 Measurement Selector Assembly ESI Part Number 42395

The Measurement Selector Assembly contains a switching arrangment to select, from VSØ, VRØ and VR9Ø, which signals will be used as the measured signal (VS) and which will be used as the reference signal (VR). These signals are then filtered and sent to the phase rectifiers.

3.2.9 Phase Rectifier Assembly ESI Part Number 4Ø668

The Phase Rectifier takes the measured signal (VS) and the reference signal (VR) and applies them through buffers to two phase rectifier circuits. The signals are rectified to produce a dc reference (VRDC) and a dc proportional to the unknown being measured (VSDC).

The dc outputs of the phase rectifiers are then fed to the A/D converter (A/D Linear Assembly ESI Part Number 4Ø2Ø2 and A/D Digital Assembly ESI Part Number 4Ø689). The A/D converter, under CPU control, measures the ratio of these dc voltages. This provides the CPU with digital information proportional to the value of selected measurement.

3.2.1Ø Measurement Modes

The analog system is operated in an admittance (Y) or impedance (Z) mode.

The Y mode measures parallel susceptance and conductance by applying a constant voltage across the unknown. This voltage is amplified by gain channel UG where it is called UA (see Figure 3-5). UA is further processed to become the reference voltage. The voltage across the

unknown produces a current proportional to the parallel conductance and susceptance of the unknown. This current is converted to a signal voltage by flowing through the standard resistor (SR) and is amplified by selectable gain channel SG. This voltage (SA) is then a measure of the unknown admittance:

$$SA=(Iunk)(SR)(SG)=(UA)(SR)(SG/UG)(Gp+jBp)$$

where $Gp = \text{Parallel Conductance of unknown} = \frac{1}{\text{Parallel Resistance}}$

and $Bp = \text{Parallel Susceptance of unknown} = \frac{1}{\text{Parallel Reactance}}$

UG = Unknown Gain SG = Standard Gain

The phase rectifiers produce dc voltages proportional to the actual measured values of Bp and Gp. All other quantities are then calculated as shown in Table 3-1.

The Z mode measures series reactance and resistance by applying constant voltage to the standard resistor, which produces a constant current. This current flows through the unknown producing a signal which is a measure of the unknown impedance and is:

$$UA=(Iref)(Zunk)(UG)$$

$$=(SA/SR)(UG/SG)(Rs + jXs)$$

The phase rectifiers produce dc voltages proportional to the actual measured values of Xs and Rs. All other quantities are then calculated as shown in Table 3-1.

	ADMITTANCE (Y BRIDGE) FUNCTION (Constant Voltage Across Unknown)		IMPEDANCE (Z BRIDGE) FUNCTION (Constant Current Thru Unknown)	
	LEFT DISPLAY	RIGHT DISPLAY	LEFT DISPLAY	RIGHT DISPLAY
MEASURED QUANTITIES	Bp	Gp	Xs	Rs
CALCULATED QUANTITIES (Calculated from Measured Quantities Above)	$Cp = \frac{Bp}{\omega}$ $Cs^* = Cp\,(1 + D^2)$	$D = \frac{Gp}{\lvert Bp \rvert}$ $Q = \frac{\lvert Bp \rvert}{Gp}$ $Rs = \frac{D}{\omega \lvert Cs \rvert}$	$Ls = \frac{Xs}{\omega}$ $Lp^* = Ls\,(1 + D^2)$	$D = \frac{Rs}{\lvert Xs \rvert}$ $Q = \frac{\lvert Xs \rvert}{Rs}$ $Gp = \frac{D}{\omega \lvert Lp \rvert}$
TEST MODE 0003 CALCULATED QUANTITIES	$Lp = \frac{-1}{\omega^2 Cp}$ $Ls^* = \frac{-1}{\omega^2 Cs}$		$Cs = \frac{-1}{\omega^2 Ls}$ $Cp^* = \frac{-1}{\omega^2 Lp}$	

*NOT CALCULATED WHEN D > 1.9999 OR Q < 0.5

Table 3-1.

3.3 THE DIGITAL SYSTEM

3.3.1 The Display Circuit Assembly, ESI Part Number 41329

This assembly contains the following circuits:

1. The microprocessor interface adaptors (temporary memory) for the display values, units and their multipliers, keyboard decoding and instrument functions and ranges.
2. The displays with their units and multipliers.
3. A 1.6 millisecond oscillator interrupt used to multiplex the displays and keyboard.
4. The L ZERO, R ZERO, C ZERO and G ZERO circuits.

3.3.1.1 Displays and Keyboard

The right and left displays and the keyboard are multiplexed at a 1.6 millisecond rate. The total time to multiplex through the display is then 10 milliseconds with each digit being energized for 16% of the

total time. This 10 millisecond total time is also used for the settling time increments. Multiplexing is accomplished by the interrupt oscillator sending a pulse to the interrupt line of the CPU. Upon receiving this pulse, the CPU performs the following operations:

1. Fetches from memory the bit pattern for the next digit, unit and multiplier for the right and left display and stores it in the appropriate latch.

2. Transfers energizing current to the next display digits.

3. Examines the keyboard to determine if a key has been pressed.

If a key has been pressed, the CPU performs a debounce routine by requiring that the key be down for five successive multiplexing times (40 milliseconds) before it will accept it.

3.3.1.2 C Zero, G Zero and L Zero, R Zero Circuits

C Zero, G Zero

The signal from unknown high sense is buffered and applied to an inverting unity gain amplifier on the display assembly. This amplifier has two potentiometers spanning its input and output (the C zero and G zero front panel trimmers) which send signals adjustable in amplitude to the null assembly. These signals are applied to the low side of the unknown through a resistor (G zero) and a capacitor (C zero). (The capacitor is variable to increase or decrease the C zero range.) The resulting currents mix with the current from the unknown to compensate for open-circuit lead or test fixture offsets.

L Zero, R Zero

The signal current from unknown low drive is sensed, inverted, buffered and applied to a second inverting unity gain amplifier on the display assembly. This amplifier also has two potentiometers spanning its input and output (the L zero and R zero front panel trimmers) and sends its signals, adjustable in amplitude, to the high assembly. These signals are mixed with the voltage across the unknown being measured through a capacitor (L Zero) and a resistor (R Zero). This allows the addition or subtraction of inductance and resistance to the measured unknown to compensate for short-circuit lead or text fixture offsets.

3.3.2 The CPU

The CPU Circuit Assembly, ESI Part number 41491, has complete control of all functions of the instrument and does all the calculations required to arrive at the desired measured quantity. It communicates with the instrument via an 8 bit bidirectional data bus. The CPU selects the circuit it needs to communicate with via a 16 bit address bus. Desired instrument functions such as range, frequency, etc., are selected on the appropriate circuit assembly by solid state switches or relays. Digital information to set these functions is stored by the CPU into temporary memory, called latches, located on the display board and other circuit assemblies as follows:

1. The CPU selects the proper latch via the address line.

2. The CPU outputs the proper bit pattern to set the desired function on the 8 bit data bus.

3. The CPU then sends a strobe pulse which stores this bit pattern into the selected latch.

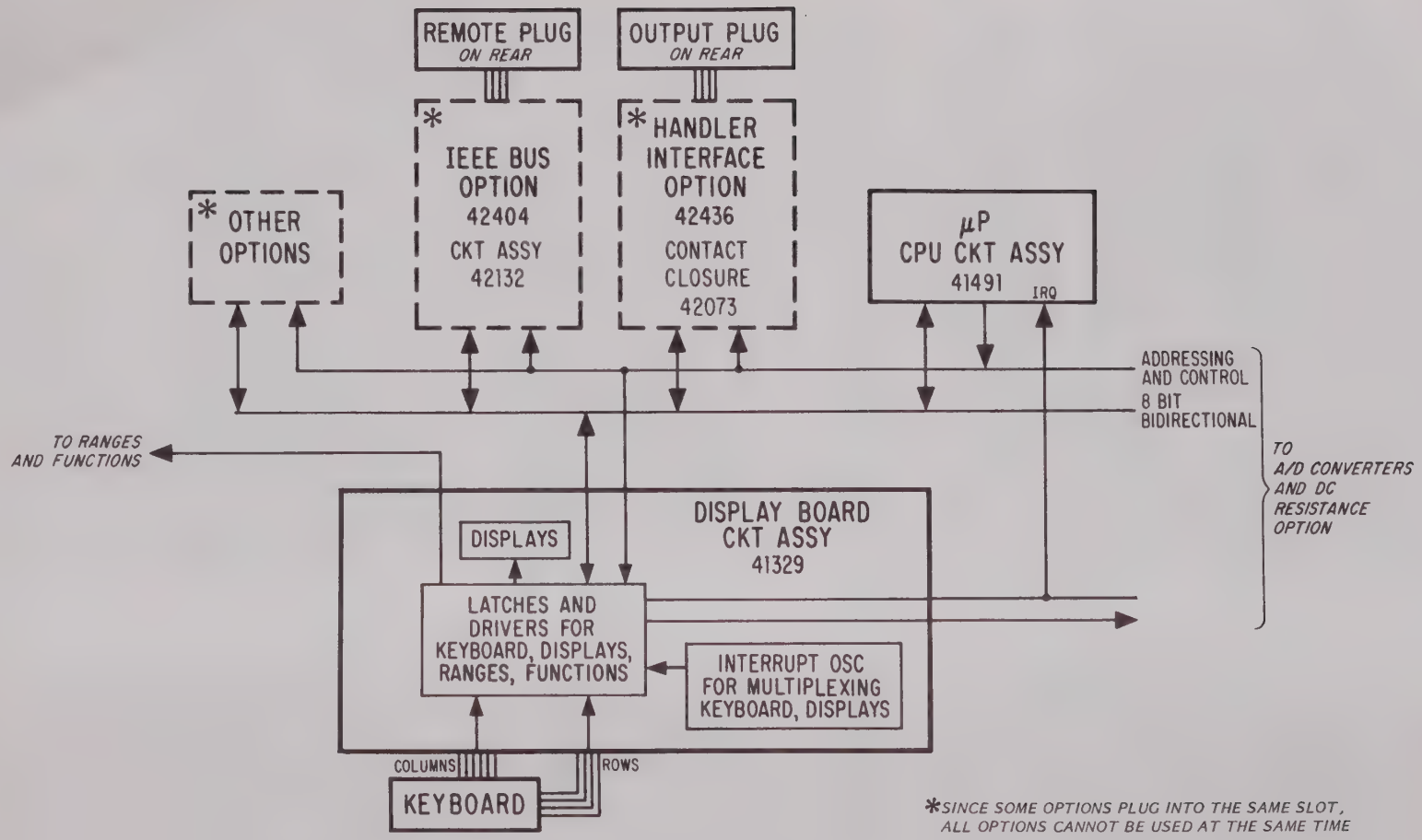

REMOTE PLUG
ON REAR
OUTPUT PLUG
ON REAR
* OTHER OPTIONS
* IEEE BUS OPTION 42404 CKT ASSY 42132
* HANDLER INTERFACE OPTION 42436 CONTACT CLOSURE 42073
μP CPU CKT ASSY 41491
IRQ
ADDRESSING AND CONTROL
8 BIT BIDIRECTIONAL
TO RANGES AND FUNCTIONS
TO A/D CONVERTERS AND DC RESISTANCE OPTION
DISPLAY BOARD CKT ASSY 41329
DISPLAYS
LATCHES AND DRIVERS FOR KEYBOARD, DISPLAYS, RANGES, FUNCTIONS
INTERRUPT OSC FOR MULTIPLEXING KEYBOARD, DISPLAYS
COLUMNS
ROWS
KEYBOARD
*SINCE SOME OPTIONS PLUG INTO THE SAME SLOT, ALL OPTIONS CANNOT BE USED AT THE SAME TIME

Figure 3-4. Digital Block Diagram

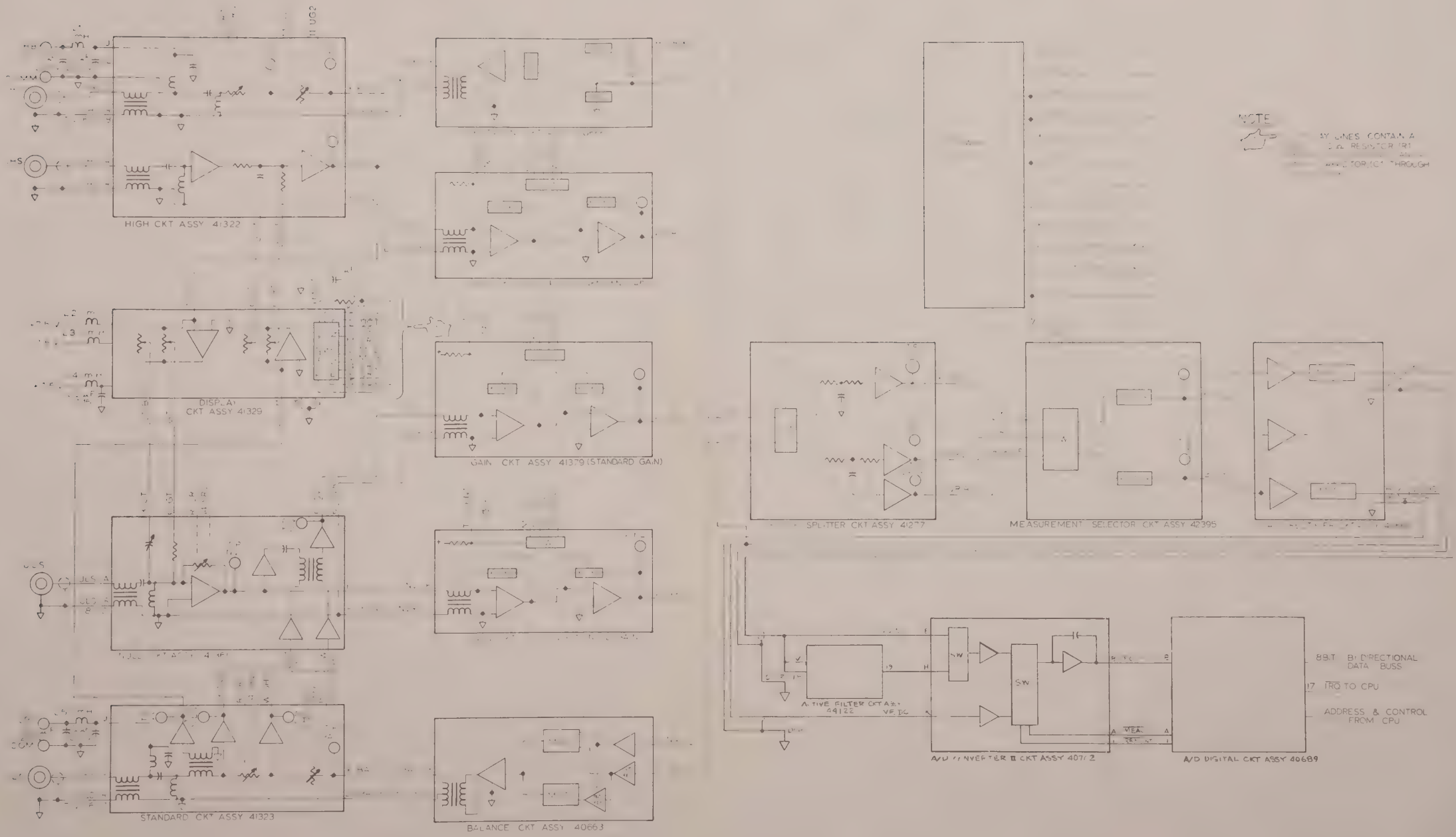


Figure 3-5. Analog Block Diagram

SECTION 4

MAINTENANCE

WARNING

INFORMATION IN THIS SECTION IS FOR QUALIFIED PERSONNEL ONLY. TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE UNLESS YOU ARE QUALIFIED TO DO SO.

4.1 CALIBRATION PROCEDURE

CAUTION

WHEN PERFORMING ANY CALIBRATION OR MAINTENANCE OPERATION, DO NOT REMOVE OR REPLACE CIRCUIT ASSEMBLIES WHILE THE POWER IS ON.

Equipment Required:

Oscilloscope
Wire for short circuit measurements
Capacitor, 160pF, ±1% CERAMIC or MICA
Capacitor, 1000pF, ±10% CERAMIC or MICA
Resistor, 1kΩ, ±1% Metal Film
Capacitance Standard, 10pF (GR type 1403-G)
Capacitance Standard, 100pF (GR type 1403-D)
Tee Connectors (Pomona Model 3285)
GR Standard Adapters (GR type 874-QBJL)

NOTE: When using GR type 1403-D (100pF) capacitance standard, add 0.03pF to its low frequency calibration value. Assume a D of 0.0002 at 1MHz for both standard capacitors.

Refer to Figure 4-1 for location of adjustments.

SET-UP

1. Connect Model 2002 test fixture to Model 410 using the BNC cables provided.

2. Turn power ON and allow 1 hour for warm-up. To minimize temperature disturbance, close cover between adjustments.

   NOTE: The following adjustments must be made in the order listed. When an adjustment is changed, all steps following must be performed.

CONVERTER ADJUSTMENT

3. Program test mode 0006.

   Push T 0 0 0 0 6 ▩ SECONDS ❑ ❑ START

4. Adjust trimmer number 3 on PCB number 18 until the left and right displays read within ±50 counts of zero.

   NOTE: Trimmer number 2 on PCB number 18 is a coarse calabration adjustment which should not be adjusted. If it is accidentally disturbed, set it to the middle of its range then proceed with normal calibration. Trimmer number 1 has no effect; it is not used in this instrument.

EXCITATION ADJUSTMENT

5. With no unknown connected, set instrument to measure 1pF.

   Push RANGE ❑ 1 ▩ p ❑ F ❑ START

6. Set to HI test voltage.

   Push ❑ HI VOLTAGE

7. Connect oscilloscope to the ~~US~~ A test point on PCB number 8.

8. Adjust trimmer number 1 on PCB number 9 for 1VRMS.

BALANCE ADJUSTMENT WHEN MAKING THIS ADJ RUN THRU RANGE TO MAKE SURE ZERO MATCHES ON EACH RANGE

9. Externally synchronize oscilloscope from ~~US~~ A test point on PCB number 8.

10. Connect oscilloscope input probe to the ~~NA~~ A test point on PCB number 2.

11. Adjust trimmer numbers 1 and 2 on PCB number 5 to eliminate the 1MHz component of the signal at ~~NA~~ A test point. (Harmonics and stray signals will remain.)

L,R,C,G ZERO ADJUSTMENTS

   NOTE: Open circuit and short circuit zero adjustments must be made with the test fixture and/or lead configuration to be used and must be repeated if the configuration is changed.

12. Set instrument to 1pF range.

   Push RANGE ❑ 1 ▩ p ❑ F ❑ START

13. Set to HI test voltage.

   Push ❑ HI VOLTAGE

✓ Ø ON EACH RANGE AND WHEN VOLTAGE IS CHANGED

14. Set to measure Cp and G (farads and siemens).

    Push ▩ F ▩ S

15. With no unknown connected, adjust the C and G front panel zero adjustments until both displays read within ±5 counts of zero.

16. Set to measure Ls and R (henrys and ohms).

    Push ▩ H ▩ Ω

17. Set to 1μH range.

    Push RANGE 1 ▩ μ H START

18. Set to MED test voltage.

    Push VOLTAGE MED

19. Insert a short hairpin-shaped wire in the test fixture.

20. Adjust the L and R front panel zero adjustments until the displays read within ±5 counts of zero.

PHASE SPLITTER ALIGNMENT

NOTE: L, R and G calibration follows inherently when the C and D alignment is performed. This eliminates the need for L and R standards.

21. Set the instrument to X/B and G measurement mode.

    Push ▩ X/B ▩ S

22. Set to HI test voltage.

    Push HI VOLTAGE

23. Set to autoranging mode.

    Push ▩ AUTO

24. Connect 160pF, ±1% capacitor to unknown terminals.

25. Alternating the measurement function between series and parallel equivalent circuit, adjust trimmer number 4 on PCB number 10 until B and -X readings average 10,000 counts in the left display.

    Push ▩ SER EQUIV CKT then PRL EQUIV CKT

26. Alternating the measurement function between series and parallel equivalent circuit adjust trimmer number 3 on PCB number 10 until G = R in the right display.

Push ▩ ❑SER EQUIV CKT then ❑PRL EQUIV CKT

27. Connect 1kΩ, ±1% resistor to the unknown terminals.

28. Alternating the measurement function between series and parallel equivalent circuit, adjust trimmer number 2 on PCB number 10 until G and R readings average 10,000 counts in the right display.

Push ▩ ❑SER EQUIV CKT then ❑PRL EQUIV CKT

29. Alternating the measurement function between series and parallel equivalent circuit, adjust trimmer number 1 on PCB number 10 until B = -X in the left display.

Push ▩ ❑SER EQUIV CKT then ❑PRL EQUIV CKT

30. Repeat steps 12 through 29 until results are as accurate as possible (within 1 or 2 counts).

CALIBRATION ADJUSTMENTS

NOTE: This calibration sequence makes all adjustments relative to 10pF and 100pF capacitance standards. Ranges and voltages not directly calibrated derive their accuracy from this procedure, and need no independent calibration.

31. Replace test fixture with tee connectors and GR standard adapters (see Figure 2-4B).

32. Set instrument to measure Cp and G (farads and siemens).

Push ▩ ❑F ▩ ❑S

33. Set to 1pF range.

Push ❑RANGE 1 ▩ ❑p ❑F ❑START

34. Set to HI test voltage

Push ❑HI VOLTAGE

35. With no unknown connected, adjust the C and G front panel zero adjustments until both displays read within ±5 counts of zero.

36. Set to measure Ls and R (henrys and ohms).

Push ▩ ❑H ▩ ❑Ω

37. Set to 1μH range.

Push RANGE ❑ 1 ▩ μ ❑ H ❑ ❑ START

38. Set to MED test voltage.

VOLTAGE
Push ❑ MED

39. Push the two GR standard adapters together.

40. Adjust the L and R front panel zero adjustments until the displays read within ±5 counts of zero.

41. Set instrument to measure Cp and D.

Push ▩ F ❑ ▩ D ❑

42. Set to HI test voltage.

Push ❑ HI
VOLTAGE

43. Set to Autoranging mode.

AUTO
Push ▩ ❑

44. Connect the 10pF standard capacitor to the unknown terminals.

45. Adjust trimmer numbers 1 and 2 on PCB number 4 until the C and D readings agree with the values of the calibrated unknown. (When using GR type 1403 capacitance standards assume a D of 0.0002 at 1MHz.)

46. Connect the 100pF standard capacitor to the unknown terminals.

47. Adjust trimmer numbers 3 and 4 on PCB number 4 until the C and D readings agree with the value of the calibrated unknown. (When using GR type 1403-D, add 0.03pF to its low frequency value and assume a D of 0.0002 at 1MHz)

48. Set to MED test voltage.

VOLTAGE
Push ❑ MED

49. Adjust trimmer numbers 1 and 2 on PCB number 8 until the C and D readings equal the HI voltage display readings for the 100pF standard capacitor.

50. Connect the 10pF standard capacitor.

51. Adjust trimmer numbers 1 and 2 on PCB number 6 until the C and D readings equal the HI voltage display readings for the 10pF standard capacitor.

52. Connect the 100pF standard capacitor.

53. Set to LO test voltage.

Push LO VOLTAGE

54. Adjust trimmer numbers 3 and 4 on PCB number 8 until the C and D readings equal the HI and MED voltage display readings for the 100pF standard capacitor.

55. Connect the 10pF standard capacitor.

56. Adjust trimmer numbers 3 and 4 on PCB number 6 until the C and D readings equal the HI and MED voltage display readings for the 10pF standard capacitor.

57. Replace the standard adapters with the Model 2002 test fixture.

NOTE: To avoid changing the test adapters, a 1000pF capacitance standard may be used, however, its low-frequency calibration value will not be usable at 1MHz.

58. Set to MED test voltage.

Push MED VOLTAGE

59. Connect the 1000pF capacitor.

60. Record the C and D readings.

61. Set instrument to HI test voltage.

Push HI VOLTAGE

62. Adjust trimmer numbers 5 and 6 on PCB number 4 until the C and D readings equal the MED voltage readings.

63. Repeat steps 31 through 62 until the results are as accurate as possible (within 1 or 2 counts).

NOTE: Capacitor C6 on PCB number 2 should normally be set to minimum capacitance for narrowest front panel C zero trim range. To accomodate test fixtures with higher zero capacitance, the trim range is increased by setting C6 to a higher capacitance value.

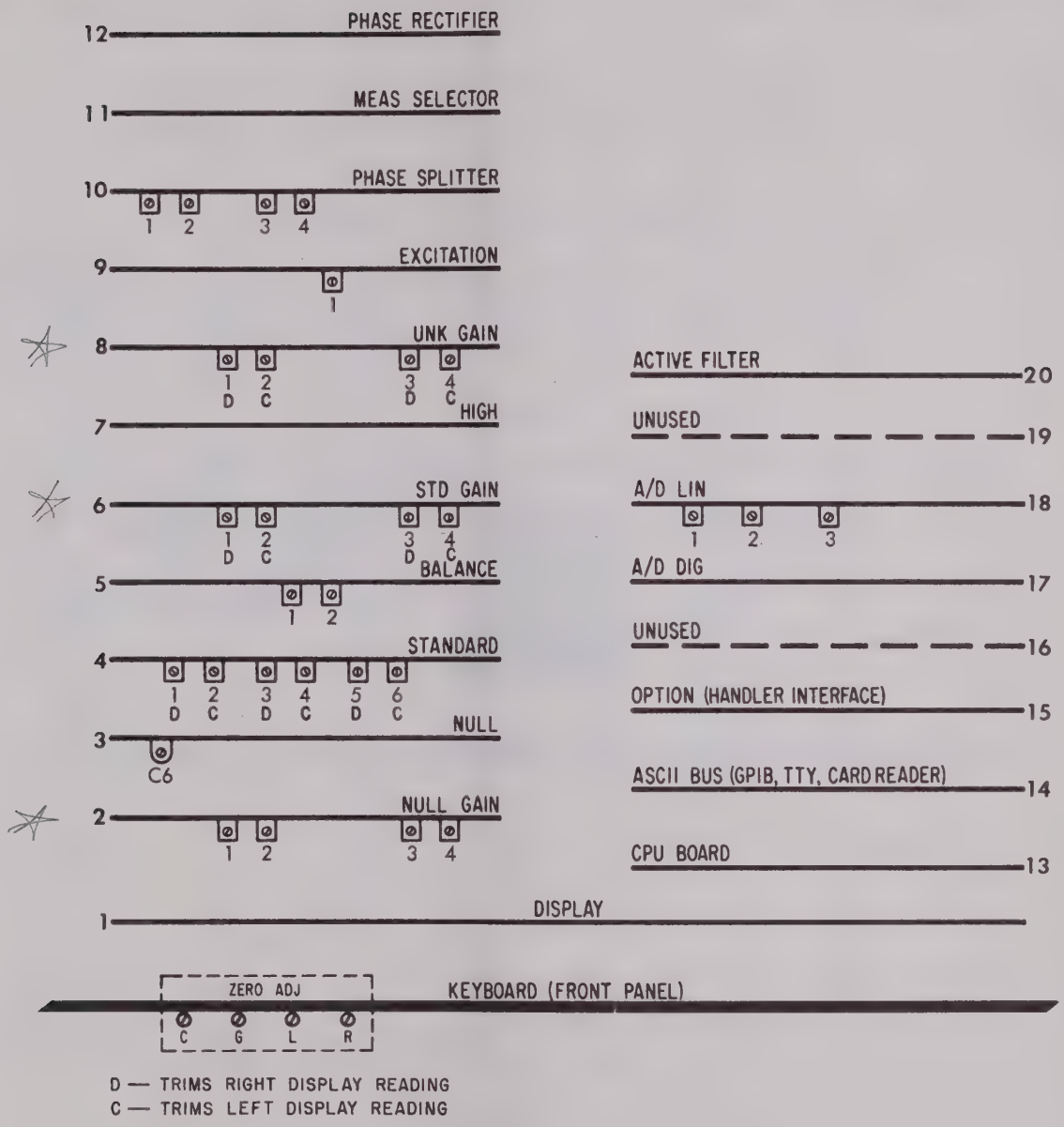

12 PHASE RECTIFIER
11 MEAS SELECTOR
10 PHASE SPLITTER
1 2 3 4
9 EXCITATION
1
8 UNK GAIN
1 D 2 C 3 D 4 C
7 HIGH
6 STD GAIN
1 D 2 C 3 D 4 C
5 BALANCE
1 2
4 STANDARD
1 D 2 C 3 D 4 C 5 D 6 C
3 NULL
C6
2 NULL GAIN
1 2 3 4
ACTIVE FILTER 20
UNUSED 19
A/D LIN 18
1 2 3
A/D DIG 17
UNUSED 16
OPTION (HANDLER INTERFACE) 15
ASCII BUS (GPIB, TTY, CARD READER) 14
CPU BOARD 13
1 DISPLAY
ZERO ADJ
C G L R
KEYBOARD (FRONT PANEL)
D — TRIMS RIGHT DISPLAY READING
C — TRIMS LEFT DISPLAY READING

Figure 4-1.

4.2 CALIBRATION SUMMARY

FUNCTION	L	C	X, R	B, G	HI TEST VOLTAGE 1V RMS (Except RANGE 1 0.1V RMS)	MED TEST VOLTAGE 0.1V RMS	LO TEST VOLTAGE 0.01V RMS (Except RANGE 5 0.1V RMS)	
UNITS	H	F	Ω	S				
RANGE NO.								
5	19.999mH	1.9999pF	125.66kΩ	12.566μS	x1	x10	x10	Unknown Gain
					x10	x100	x100	Standard Gain
					10kΩ	10kΩ	10kΩ	Standard Resistor
4	1.9999mH	19.999pF	12.566kΩ	125.66μS	x1	x10	x100	Unknown Gain
					x1	x10	x100	Standard Gain
					10kΩ	10kΩ	10kΩ	Standard Resistor
					45	51	56	Calibration Step No.
					10pF	10pF	10pF	Unknown (Standard)
					1 and 2	1 and 2	3 and 4	Trimmer No.
					4	6	6	PCB No.
3	199.99μH	199.99pF	1.2566kΩ	1.2566mS	x1	x10	x100	Unknown Gain
					x1	x1	x10	Standard Gain
					1kΩ	10kΩ	10kΩ	Standard Resistor
					47	49	54	Calibration Step No.
					100pF	100pF	100pF	Unknown (Standard)
					3 and 4	1 and 2	3 and 4	Trimmer No.
					4	8	8	PCB No.
2	19.999μH	1.9999nF	125.66Ω	12.566mS	x1	x10	x100	Unknown Gain
					x1	x1	x1	Standard Gain
					100Ω	1kΩ	10kΩ	Standard Resistor
					61	59		Calibration Step No.
					1000pF	1000pF		Unknown (Standard)
					5 and 6	(Note Readings)		Trimmer No.
					4			PCB No.
1	1.9999μH	19.999nF	12.566Ω	125.66mS	x10	x10	x100	Unknown Gain
					x1	x1	x1	Standard Gain
					100Ω	100Ω	1kΩ	Standard Resistor

Table 4-1. Calibration Summary

4.3 AIR FILTER MAINTENANCE

The air filter is located on the rear panel (see Figure 4-2). It should be visually inspected every 90 days and cleaned or replaced if necessary.

To clean or replace:

1. Turn instrument power off.
2. Slide filter out from behind the fan finger guard.
3. Clean filter by shaking or blowing air across it.
4. Reinstall by sliding filter into place behind the finger guard.

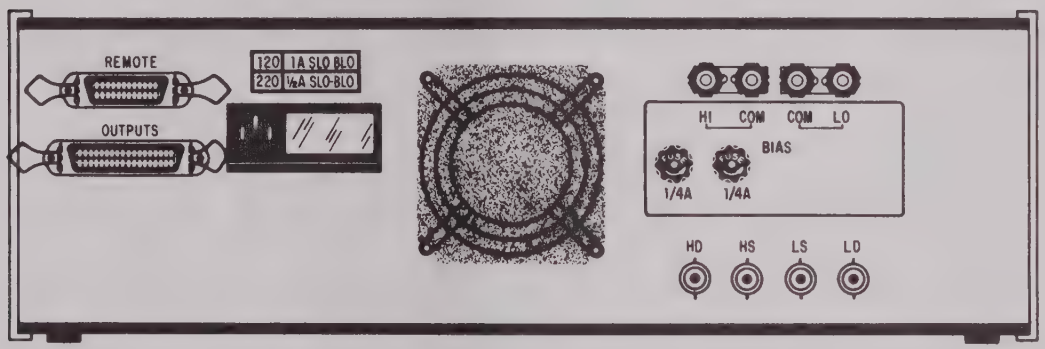


Figure 4-2. Model 410 Rear Panel

SECTION 5

PARTS LIST AND DIAGRAMS

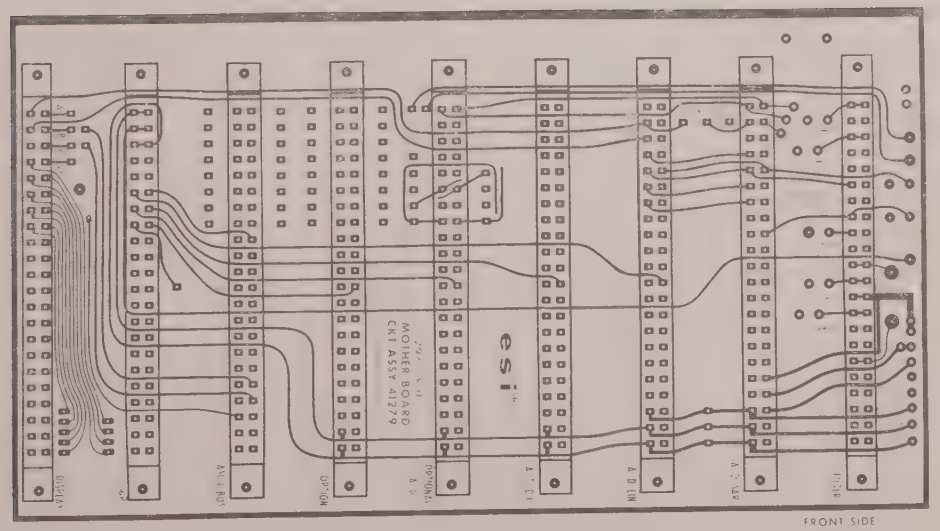
5.1 MAINFRAME PARTS

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
F1	Fuse Ø.1A, Slo-Blo	Ø9227
FL	Fuse, Ø.25A	Ø1812
FL1	Filter, Receptacle, Fused	4ØØØ2
S1	Switch, Power	23164
T1	Transformer, Power 41226	41226
	Circuit Assembly, Right Hand Mother Board	41279
	Circuit Assembly, Display Board	41329
	Circuit Assembly, CPU	43378
	Circuit Assembly, A/D Converter (Digital)	4Ø689
	Circuit Assembly, A/D Converter II (Analog)	4Ø7Ø2
	Circuit Assembly, Active Filter	44122
	Circuit Assembly, Keyboard	41269
	Circuit Assembly, Power Supply	41693
	Circuit Assembly, Left Hand Mother Board	41288
	Circuit Assembly, Gain	41379
	Circuit Assembly, Null	4136Ø
	Circuit Assembly, Standard	41324
	Circuit Assembly, Balance	4Ø663
	Circuit Assembly, High	41322
	Circuit Assembly, Excitation	4Ø666
	Circuit Assembly, Phase Splitter	41277
	Circuit Assembly, Measurement Selector	42395
	Circuit Assembly, Phase Rectifier	4Ø668
	Front Panel	41795
	Back Panel	41282
	Top Cover	41264
	Bottom Cover	41265
	Bezel	41263
	Side Cabinet	41266
	PCB Rails	413Ø7
	Card Guide Rails 13.Ø Inch	41496
	Card Guide Rails 9.Ø Inch	41495
	Front Panel, Display	41744
	Keyboard Kit	41369
	Button, Push (White)	41191
	Button, Push (Red)	41557
	Center Rail, Left Hand	41697
	Center Rail, Right Hand	41698
	Card Guide	41846
	Instruction Card, Pull-out	43312
	Bracket, Power Switch	41487
	Strip, Cover	42415
	Bail	24ØØ7
	Feet	Ø8739

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	Bracket, Transformer Mounting	41595
	Pushrod	24866
	Fan	27829
	BNC Connectors	41820
	Finger, Guard, Fan	41552
	Panel, Binding Posts	43309
	Display Panel (plastic)	42626
	Binding Post	01435
	Line Cord	24077
	Instruction Manual	43311
	Filter, Fan	41527
	Heatsink, Regulator	41706
	Diode, MR 1121	25688
	Diode, Mounting Kit	29534
	Socket	12262
	Capacitor, 0.22µF, Disc, 100V,	13680
	Capacitor, 22µF, 20V,	13283
	Capacitor, 8000µF, 15V	21216
	Capacitor, 0.1µF, 200V	12121
	Regulator, LM323k	24010
	Regulator, LM340T-5	20699
	Regulator, LM34/P-12	41877
	Regulator, LM320T-5	41876
	Fuse Holder	03074
	Connector, 24 Pin	42407
	Connector, 36 Pin	15739
	ESI Medallion	01946
	Shield, PCB	41469

5.2 CIRCUIT ASSEMBLY, RH MOTHER BOARD (Part No. 41279)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
	Connector, 44 Pin	27817



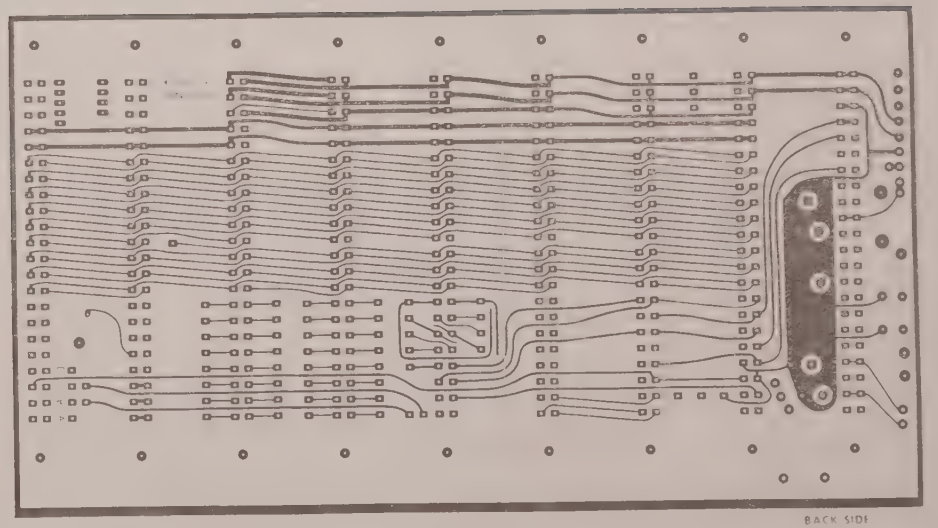


Figure 5-1. Ckt Assy, Right-Hand Mother Board (Parts Placement), Part No. 41279

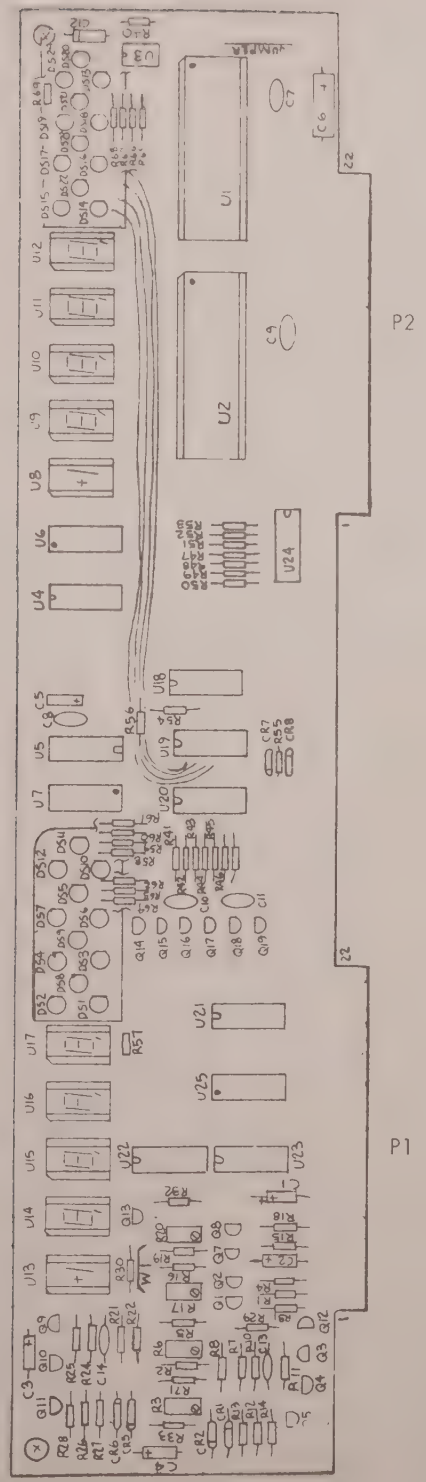
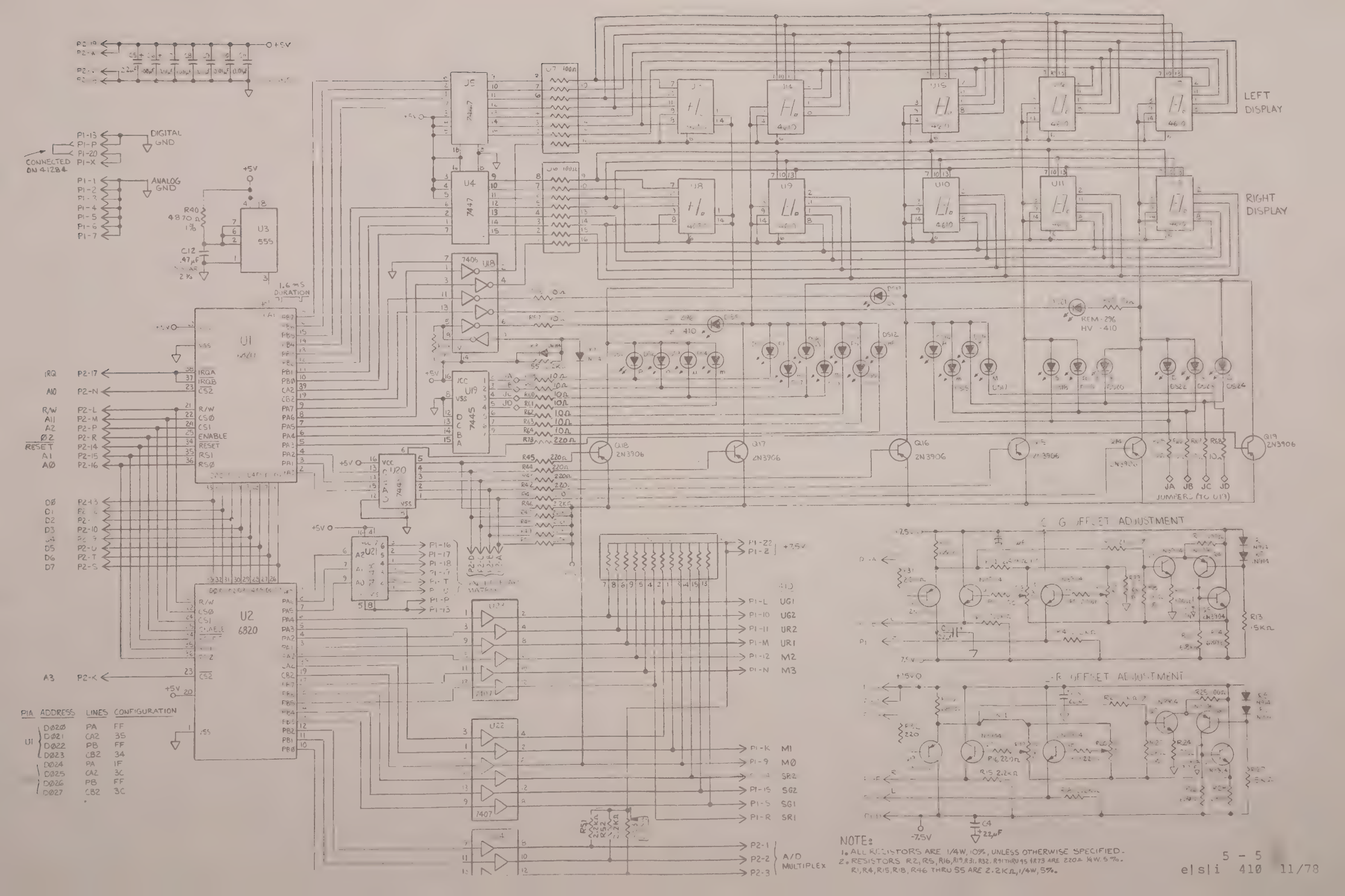


Figure 5-2. Circuit Assembly Display Board, Part No. 41329

5.3 CIRCUIT ASSEMBLY, DISPLAY BOARD (Part No. 41329)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C2-C5	Capacitor, 22µF, 10V, Tant	18852
C6	Capacitor, 100µF, Electrolytic, 12V	06157
C7-C11	Capacitor, 0.01µF, Disc Ceramic, 50V	12144
C12	Capacitor, 0.47µF, 100V, 10%	13653
C13,14	Capacitor, 3.3pF, Disc	01925
CR1,2,5-8	Diode, 1N914A	12356
DS1-24	LED, PC Mount	41377
Q1-3,5, 7-9,11	Transistor, 2N3904	18751
Q4,10,12-19	Transistor, 2N3906	18754
R1,4,15,18,46-55	Resistor, 2.2kΩ, 5%, 1/4W	13924
R2,5,16,19,31,32 41-45,73	Resistor, 220Ω, 5%, 1/4W	13911
R3,6,17,20	Trimpot, 10kΩ, 20 Turn	41902
R7,8,21,22	Resistor, 2kΩ, 1%, 1/4W	21733
R10,11,24,25	Resistor, 100Ω, 10%, 1/4W	13907
R12,26	Resistor, 6.8kΩ, 10%, 1/4W	13930
R13,27	Resistor, 15kΩ, 10%, 1/4W	13935
R14,28-30	Resistor, 680Ω, 10%, 1/4W	13917
R33	Resistor, 806Ω, 1%, 1/4W	21729
R40	Resistor, 4870Ω, 1%, 1/4W	20660
R56-69	Resistor, 10Ω, 10%, 1/4W	13895
R71	Resistor, 2.49kΩ, 1%, 1/4W	21734
U1,2	IC, 6820, PIA, AMI, 40 Pin	41292
U3	IC, 555, Timer	20721
U4,5	IC, 7447, BCD to Seven Segment Decoder	20691
U6,7	Resistor, DIP Pack, 8 ea, 100Ω	20714
U8,13	Display, ±1, Monsanto 4630	41349
U9-12,14-17	Display, Seven Seg, Monsanto 4610	41350
U18	IC, 7406, Hex Inverter, Open Coll	20678
U19,20	IC, 7445, BCD to Decimal Decoder	20609
U21	IC, 74148, Priority Encoder	41347
U22-U24	IC, 7407	24076
U25	Resistor, DIP Pack, 15 ea, 3.3kΩ	22947
	LED Alignment Block, Lefthand	42398
	LED Alignment Block, Righthand	42397
	Shield, PC Board	41467
	Socket, 14 Pin DIP, PC Mount	19189
	Socket, 40 Pin DIP, PC Mount	41342


LEFT DISPLAY
RIGHT DISPLAY
DIGITAL GND
ANALOG GND
CONNECTED ON 4-12-84
+5V
1.6 mS DURATION
REM-296
HV -410
JA JB JC JD
JUMPERS (TO U13)
G OFFSET ADJUSTMENT
R OFFSET ADJUSTMENT
-7.5V
NOTE:
1. ALL RESISTORS ARE 1/4W, 10%, UNLESS OTHERWISE SPECIFIED.
2. RESISTORS R2, R5, R16, R19, R31, R32, R91 THRU 95 AND R73 ARE 220Ω 1/4W 5%.
R1, R4, R15, R18, R46 THRU 55 ARE 2.2KΩ, 1/4W, 5%.
PIA ADDRESS LINES CONFIGURATION
U1 DØ20 CA2 3S
DØ21 PA FF
DØ22 PB FF
DØ23 CB2 34
DØ24 PA 1F
DØ25 CA2 3C
DØ26 PB FF
DØ27 CB2 3C
A/D MULTIPLEX

5.4 CIRCUIT ASSEMBLY, CPU BOARD (Part No. 41491)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, C2	Capacitor, Ø.1µF, 2ØØV, Mylar	12121
C3, C4	Capacitor, 1ØØpF, 6ØØV, Poly	18760
C5	Capacitor, Ø.47µF, 5ØV	13653
C6-C8, C1Ø	Capacitor, Ø.Ø1µF, 5ØV, Ceramic	12144
C9	Capacitor, 1ØØµF, Electrolytic, 12V	Ø6157
R1	Resistor, 3.3kΩ, 1Ø%, 1/4W	13926
R2, R3	Resistor, 1MΩ, 1Ø%, 1/4W	13960
R4-R6	Resistor, 1.2kΩ, 1Ø%, 1/4W	13921
R7, R8	Resistor, 12.4kΩ, 1%, 1/4W, Metal Film	21741
R9	Resistor, 4.7kΩ, 1Ø%, 1/4W	13927
R1Ø	Resistor, 3.9kΩ, 1Ø%, 1/4W	13929
U1-U4	CPU Prom Set	43714
U5	IC, 68ØØ, Microprocessor	41290
U6, U7	IC, 6810, RAM	41291
U8	IC, 86Ø2	41514
U1Ø	IC, 74ØØ	2Ø6ØØ
U11	IC, 555, Timer	2Ø721
U12	IC, MC3459, HI Cap Driver	41513
U13, U19	IC, 7442, Decoder	2Ø6Ø8
U14-U17	IC, 8T97, Hex Bus Buffer	41515
	Socket, 24 Pin DIP, Solder Tail	41492
	Socket, 4Ø Pin DIP, Solder Tail	41342

NOTES:

1. ALL RESISTORS ARE 1/4 W, 10% AND MEASURED IN OHMS UNLESS OTHERWISE SPECIFIED

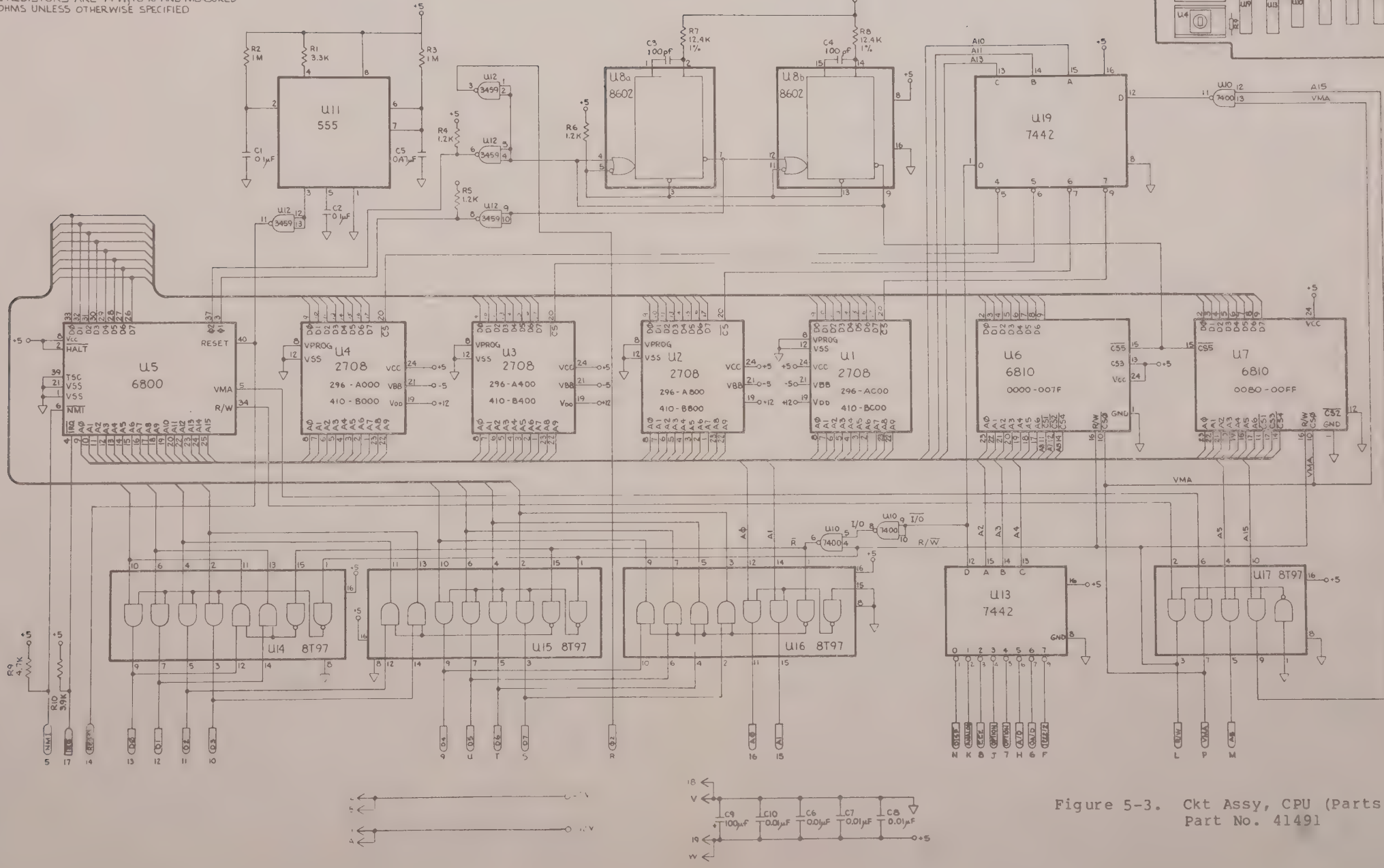
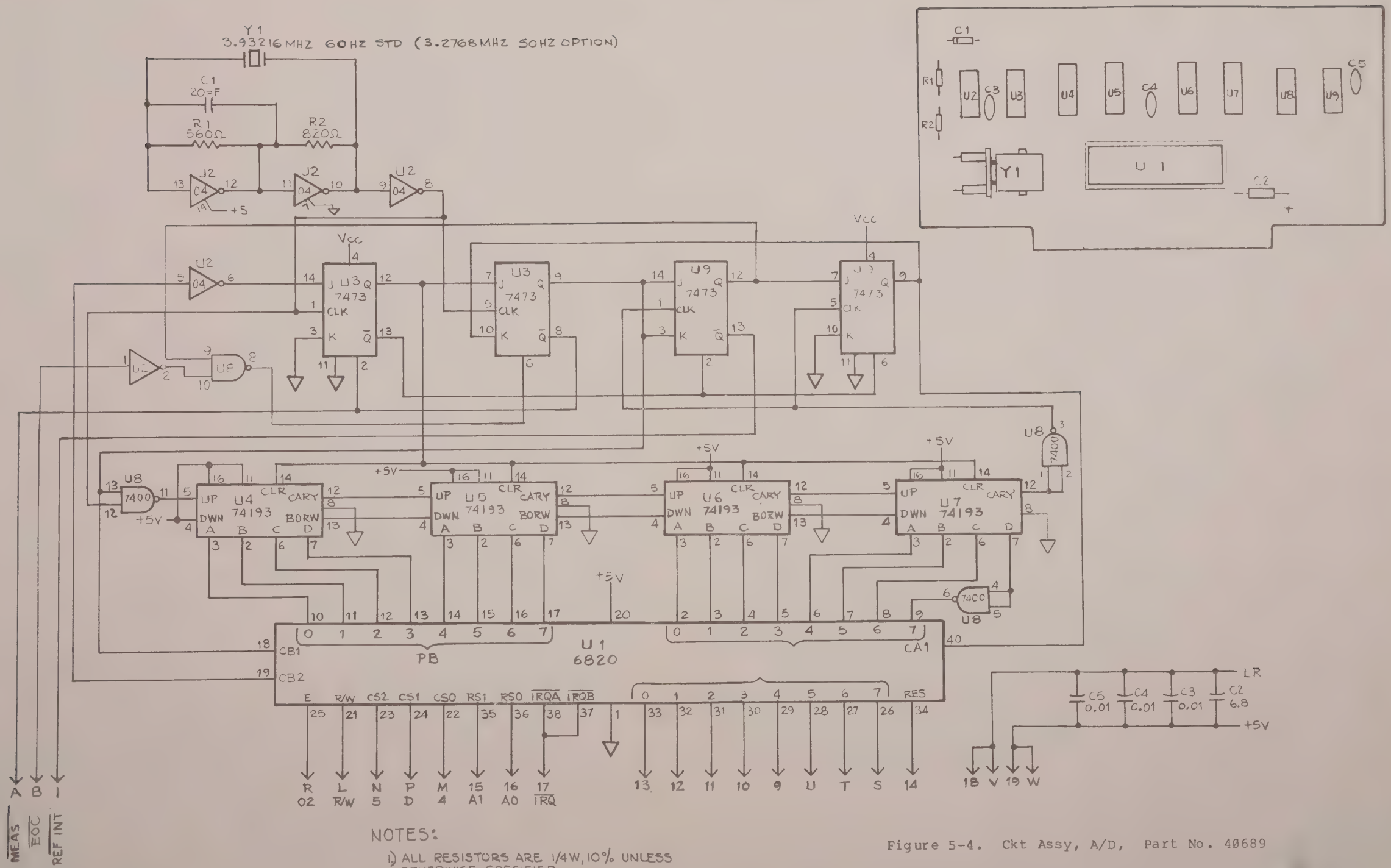


Figure 5-3. Ckt Assy, CPU (Parts Placement)
Part No. 41491

5.5 CIRCUIT ASSEMBLY, A/D CONVERTER (Part No. 40689)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 20pF, 600V, Poly	20926
C2	Capacitor, 6.8µF, 35V, Tant	25339
C3-C5	Capacitor, 0.01µF, 50V, Disc	12144
R1	Resistor, 560Ω, 10%, 1/4W, CC	13916
R2	Resistor, 820Ω, 10%, 1/4W, CC	13919
U1	IC, 6820	41292
U2	IC, 7404	20695
U3, U9	IC, 7473	20613
U4-U7	IC, 74193	20677
U8	IC, 7400	20600
Y1	Crystal, 3.93216MHz (60Hz)	24399 (Std)
	Crystal, 3.2768MHz (50Hz)	24540 (Opt)
	Socket, Crystal	24444
	Socket, IC 40 Pin	41342



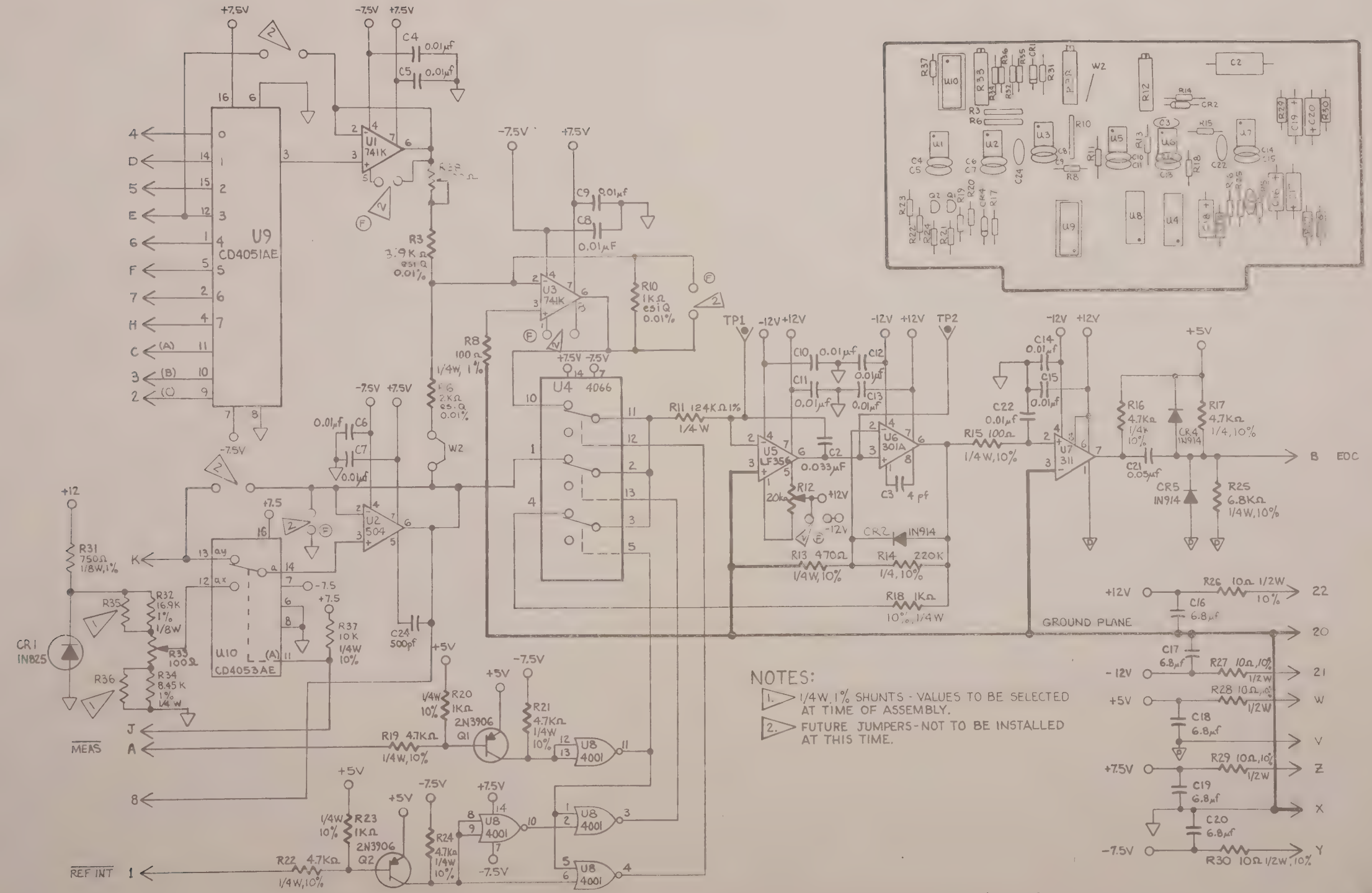
NOTES:

1) ALL RESISTORS ARE 1/4W, 10% UNLESS OTHERWISE SPECIFIED.
2) ALL CAPACITORS ARE MEASURED IN μF UNLESS OTHERWISE SPECIFIED.

Figure 5-4. Ckt Assy, A/D, Part No. 40689

5.6 CIRCUIT ASSEMBLY, A/D CONVERTER II (ANALOG) (Part No. 40702)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C2	Capacitor, 0.033µF, 400V, Poly	26097
C3	Capacitor, 4pF, 500V, Disc	02126
C4-C15, C22	Capacitor, 0.01µF, 50V, Disc	12144
C16-C20	Capacitor, 6.8µF, 35V, Tant	25339
C21	Capacitor, 0.05µF, 50V, Disc	12116
C24	Capacitor, 500pF, 50V, Disc	12043
CR1	Diode 1N825	20868
CR2, CR4, CR5	Diode 1N914A	12356
Q1, Q2	Transistor, 2N3906	18754
R3	Resistor, 3.9kΩ, 0.01%, ESI Q	42875
R6	Resistor, 2kΩ, 0.01%, ESI Q	42630
R8	Resistor, 100Ω, 1%, 1/4W	21720
R10	Resistor, 1kΩ, 0.01%, ESI Q	42631
R11	Resistor, 124kΩ, 1%, 1/4W, Film	21751
R12	Potentiometer, 20kΩ	21199
R13	Resistor, 470Ω, 10%, 1/4W	13915
R14	Resistor, 220kΩ, 10%, 1/4W	13949
R15	Resistor, 100Ω, 10%, 1/4W	13907
R16, R17, R19, R21, R22, R24	Resistor, 4.7kΩ, 10%, 1/4W	13927
R18, R20, R23	Resistor, 1KΩ, 10%, 1/4W	13920
R25	Resistor, 6.8kΩ, 10%, 1/4W	13930
R26-R30	Resistor, 10Ω, 10%, 1/2W	02039
R31	Resistor, 750Ω, 1%, 1/8W	25999
R32	Resistor, 16.9kΩ, 1%, 1/8W	25290
R33	Potentiometer, 100Ω	26853
R34	Resistor, 8.45kΩ, 1%, 1/4W	83288
R35, R36	Resistor, 1%, 1/4W	Select
R37	Resistor, 10kΩ, 10%, 1/4W	13933
R38	Potentiometer, 200Ω	12083
U1, U3	Op-Amp, 741K	21625
U2	Op-Amp, AD504J	20697
U4	CMOS Switch, 4066AE	41761
U5	Op-Amp, LF356	41473
U6	Op-Amp, 301A	20669
U7	Op-Amp, 311N	29544
U8	CMOS Gate, 4001AE	40842
U9	CMOS Switch, 4051AE	40841
U10	CMOS Switch, CD4053	20744
W1, W2	Wire	06091



NOTES:

1. 1/4W, 1% SHUNTS - VALUES TO BE SELECTED AT TIME OF ASSEMBLY.
2. FUTURE JUMPERS - NOT TO BE INSTALLED AT THIS TIME.

Figure 5-5. Ckt Assy, A/D Analog, Part No. 40702

5.7 CIRCUIT ASSEMBLY, ACTIVE FILTER (Part No. 44122)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,2	Capacitor, 200µF, 15V	15838
R1,2	Resistor, 10Ω, 10% 1/2W,	Ø2Ø39
R3	Resistor, 1kΩ, Ø.Ø1%, ESI QB	27193
R4	Resistor, 9kΩ, Ø.Ø1%, ESI QB	22Ø32
U1	Op Amp 741	2Ø668
	IC Socket, 8 Pin	224Ø
	Mylar Cover	753Ø6
	Screw, 4-4Ø x Ø.25LG. PHP	Ø3629
	Shield, PCB	41469
	Washer, No. 4 Lock	Ø3577

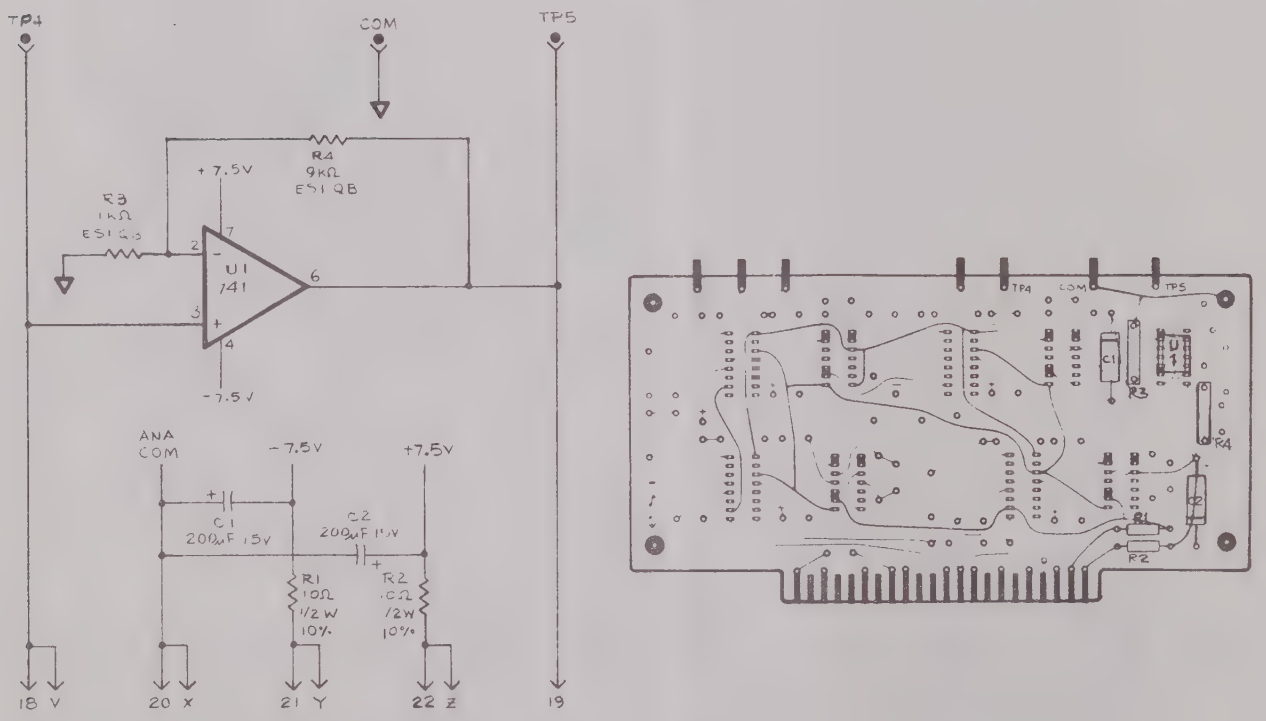
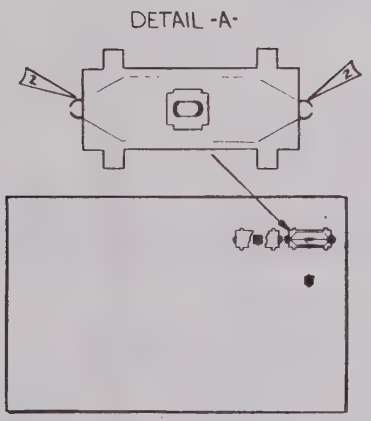


Figure 5-6. Circuit Assembly Active Filter, Part No. 44122

5.8 CIRCUIT ASSEMBLY, KEYBOARD (Part No. 41269)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Keyboard Switch	41656
	Switch Contact	41655



NOTE:

1. INSTALL SWITCH CONTACT (ITEM 3) TO MOUNT FLUSH AGAINST PCB AND ALIGNED WITH SWITCH (ITEM 2), SEE DETAIL A.

2. INSTALL SWITCH (ITEM 2) USEING TOOL # 41269 (REWORKED MANUFACTURE SUPPLIED TOOL). IF HAND INSTALLATION IS NECESSARY; APPLY PRESSURE ON SWITCH MTG BARREL 2, DO NOT PRESS IN THE CENTER OF THE SWITCH.

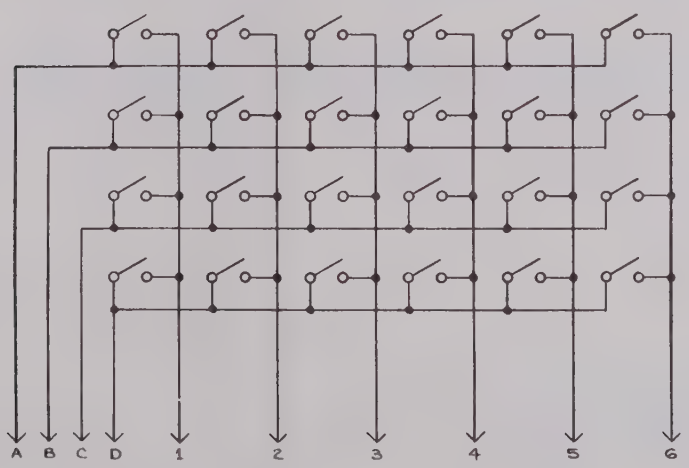


Figure 5-7. Ckt Assy, Keyboard, Part No. 41269

5.9 CIRCUIT ASSEMBLY, POWER SUPPLY (Part No. 41693)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, C2	Capacitor, 4000µF, 25V	26082
C3-C5	Capacitor, 500µF, 50V	01942
C6-C10, C17	Capacitor, 2.2µF, 20V, Tant	13283
C11-C16	Capacitor, 0.22µF, Disc	13680
CR1, CR2	Rectifier, Bridge, 6A, FLWD 200	27824
CR3, CR4	Rectifier, Bridge, 1.5A	21236
CR5, CR6	Diode, 1N4005	01779
R1, R2	Trimpot, 100Ω	
R3, R4	Resistor, 150Ω, 10%, 1/2W	15970

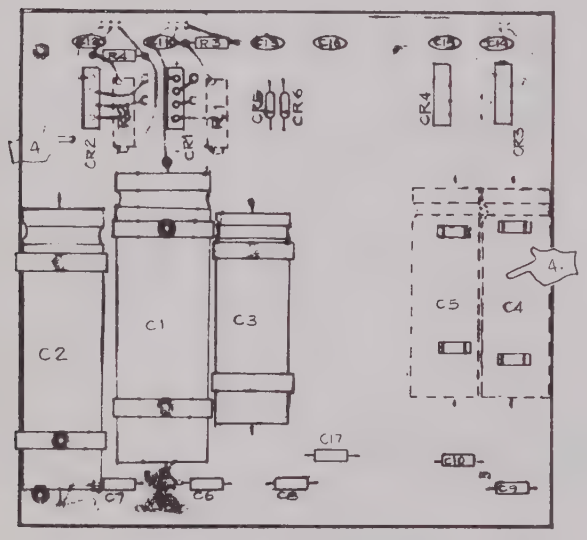
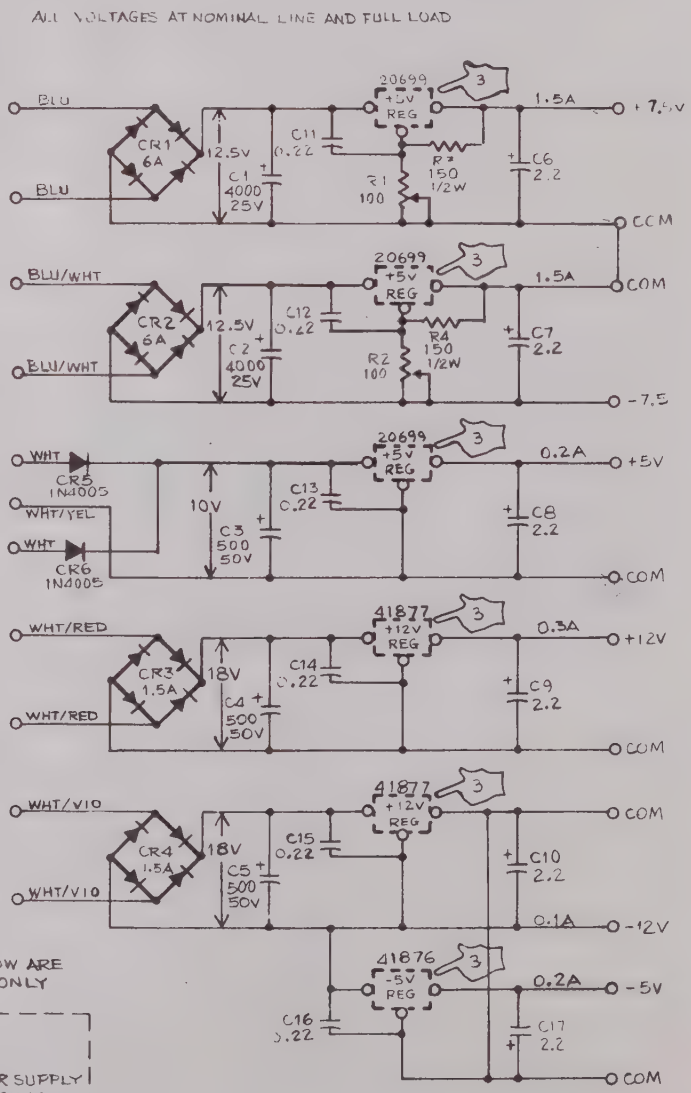
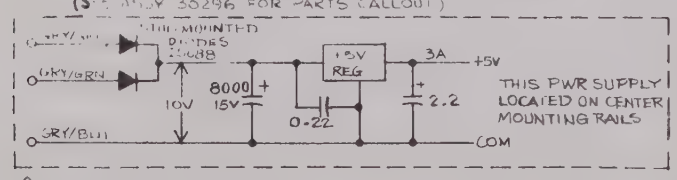


Figure 5-8. Ckt Assy, Power Supply, Part No. 41693



NOTE;

1. ALL RESISTOR VALUES ARE IN OHMS
2. ALL CAPACITORS ARE IN µF UNLESS OTHERWISE STATED
3. POWER SUPPLY COMPONENTS & SECTIONS NOTED BELOW ARE NOT LOCATED ON ASSY 41693 & ARE SHOWN FOR REF ONLY (SEE ASSY 50296 FOR PARTS CALLOUT)



4. C4 AND C5 MOUNTED ON BACK SIDE OF BOARD

5.10 CIRCUIT ASSEMBLY, LH MOTHER BOARD (Part No. 41288)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, 2	Capacitor, 0.1µF, 200V, Mylar	12121
C3-14	Capacitor, 0.05µF, 50V, Disc	12116
C15	Capacitor, 22µF, 15V, Tant	18852
L1-5	Inductor, 1mH	43163
R1-12	Resistor, 100Ω, 10%, 1/4W	13907
	Connector, 44 Pin	27817
	Cable, Coax	06260

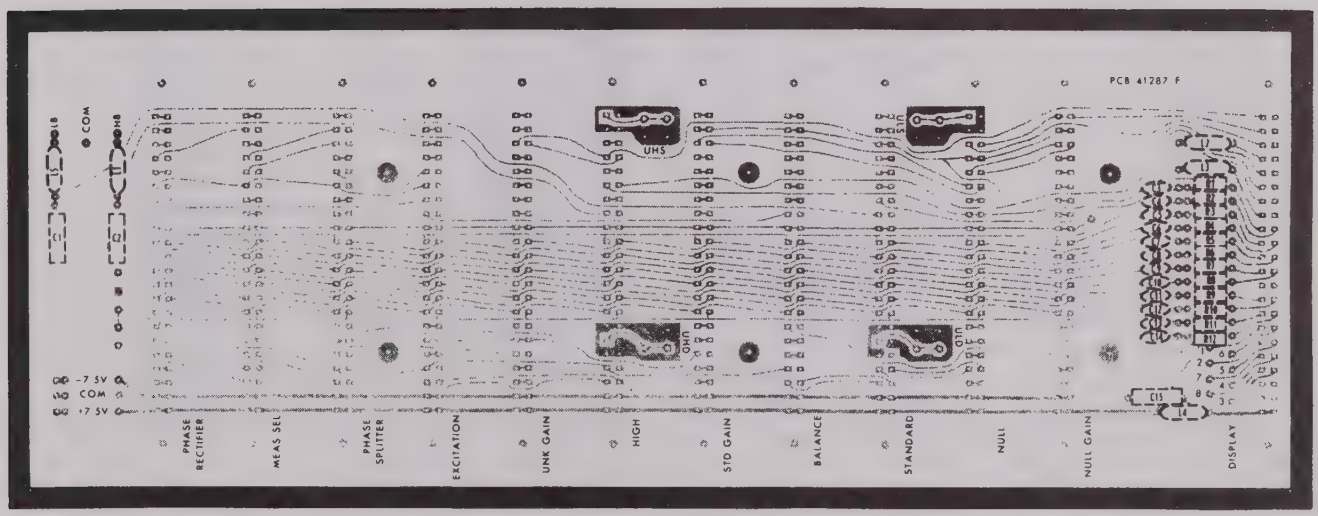
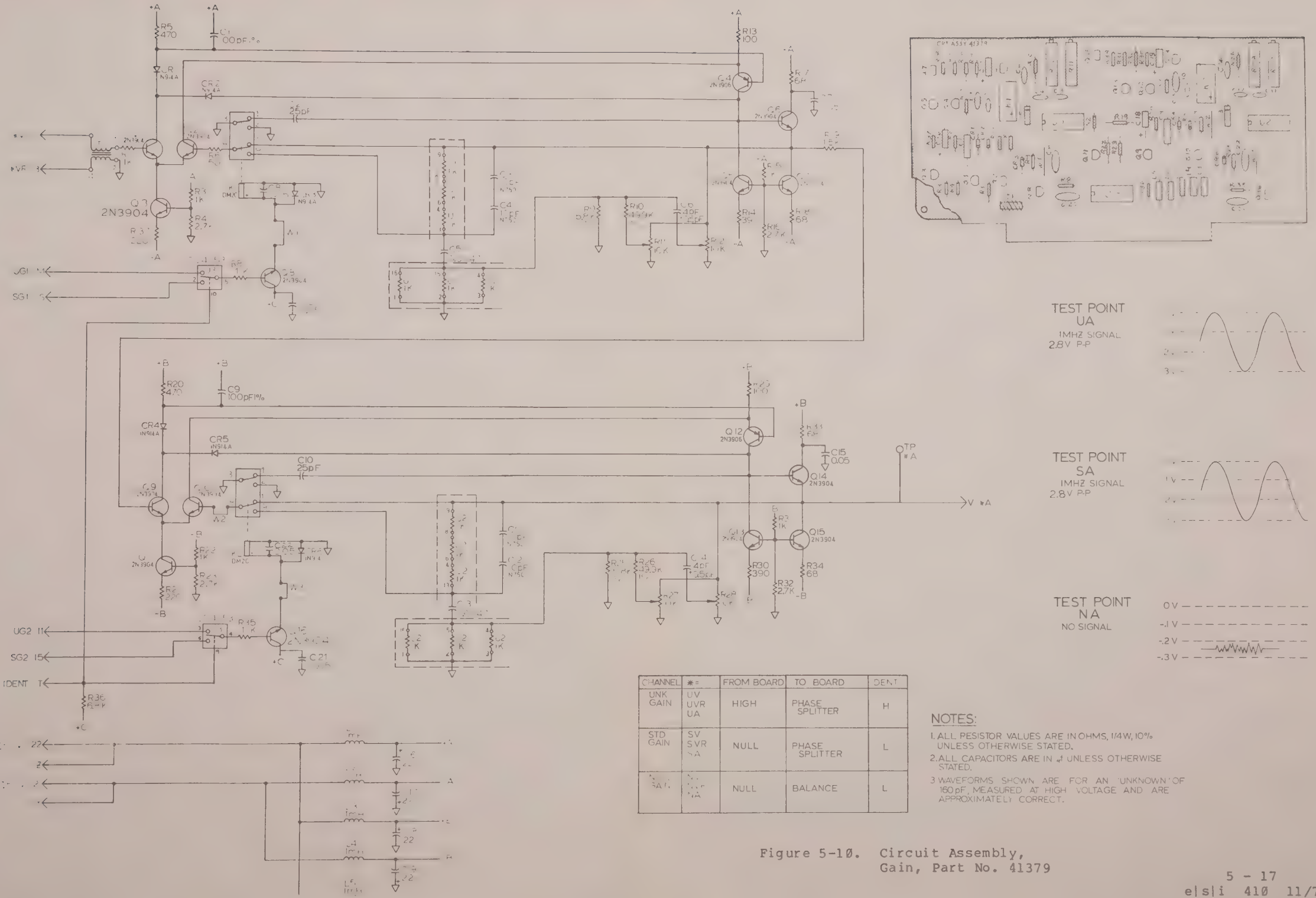


Figure 5-9. Circuit Assembly Mother Board, Part No. 41288

5.11 CIRCUIT ASSEMBLY, GAIN (Part No. 41379)

CIRCUIT_NO.	DESCRIPTION	ESI_PART_NO.
C1,9	Capacitor, 100pF, 1% Mica	01933
C2,10	Capacitor, 25pF, 1kV, Disc	01924
C3,4,11,12	Capacitor, 10pF, 1kV, Temp. Comp.	43130
C5,13	Capacitor, 0.0047µF, 100V	13299
C6,14	Capacitor, 4pF, ±0.5pF	02126
C7,8,15,20-22	Capacitor, 0.05µF, 50V, Disc	12116
C16-19	Capacitor, 22µF, 15V, Tant	18852
R1,3,8,15,22 31,35	Resistor, 1kΩ, 10%, 1/4W	13920
R4,16,23,32	Resistor, 2.7kΩ, 10%, 1/4W	13925
R5,20	Resistor, 470Ω, 10%, 1/4W	13915
R6	Resistor, 150Ω, 10%, 1/4W	13909
R9,25	Resistor, 15.8kΩ, 1%, 1/4W	21742
R10,26	Resistor, 49.9kΩ, 1%, 1/4W	21747
R11,12,27,28	Resistor, 10kΩ, Trimpot	20145
R13,29	Resistor, 100Ω, 10%, 1/4W	13907
R14,30	Resistor, 390Ω, 10%, 1/4W	13914
R17,18,33,34	Resistor, 68Ω, 10%, 1/4W	13902
R19	Resistor, 1.5kΩ, 10%, 1/4W	13922
R21,37	Resistor, 220Ω, 10%, 1/4W	13911
R36	Resistor, 6.8kΩ, 10%, 1/4W	13930
U1,2	Resistor, 1kΩ, 0.5%, Resistor Network	43117
T1	Transformer, 13T, 2 Strand	42873
CR1-6	Diode 1N914A	12356
Q1-3,5-11,13-16	Transistor, 2N3904	18751
Q4,12	Transistor, 2N3906	18754
U3	Relay, CD3053	20744
K1,2	Relay, DM2C	41517
W1-3	Wire	06091



TEST POINT
UA
1MHZ SIGNAL
2.8V P-P

TEST POINT
SA
1MHZ SIGNAL
2.8V P-P

TEST POINT
NA
NO SIGNAL

CHANNEL	*=	FROM BOARD	TO BOARD	DENT
UNK GAIN	UV UVR UA	HIGH	PHASE SPLITTER	H
STD GAIN	SV SVR SA	NULL	PHASE SPLITTER	L
BAL	*A	NULL	BALANCE	L

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μf UNLESS OTHERWISE STATED.
3. WAVEFORMS SHOWN ARE FOR AN 'UNKNOWN' OF 160 pF, MEASURED AT HIGH VOLTAGE AND ARE APPROXIMATELY CORRECT.

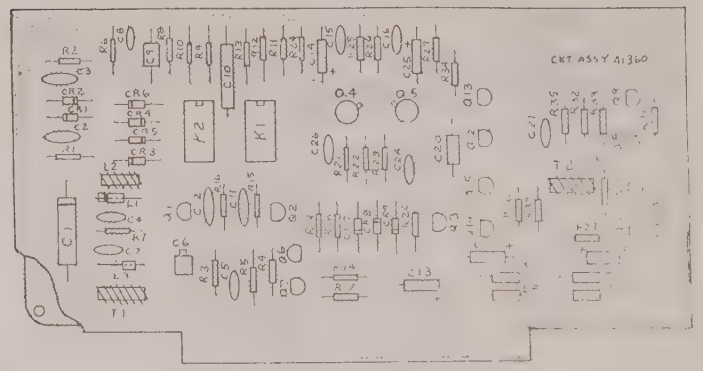
Figure 5-10. Circuit Assembly, Gain, Part No. 41379

5.12 CIRCUIT ASSEMBLY, NULL (Part No. 41360)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 0.015µF, 600V	42936
C2,3,4,11,12,15, 16,21,24,26	Capacitor, 0.05µF, 50V, Disc	12116
C5,7	Capacitor, 25pF, 1kV, Disc	01924
C6	Capacitor, 0.8-4.5pF, Piston Trimmer	43132
C8	Capacitor, 10pF, 1%, Mica	42934
C9	Capacitor, 2.2pF, 1%, Vit	09063
C10	Capacitor, 200pF, 1%, Mica	20880
C13,C14,20,22 23,25	Capacitor, 22µF, 15V, Tant	18852
CR1,2,7,8,9	Diode, IN914A	12356
CR3-6	Diode, MPD300	13639
K1,2	Relay, GB821A-2	27841
L2	Inductor, 229µF, 20T, Coil	42872
L3-7, 1A, 1B	Ferrite Bead, Large	42937
L8-11	Inductor, 1mH	43163
R1,2	Resistor, 10kΩ, 10%, 1/4W	13933
R3	Resistor, 27kΩ, 10%, 1/4W	13938
R4	Resistor, 8.2kΩ, 10%, 1/4W	13932
R5	Resistor, 200kΩ, 1%, 1/4W	21753
R6,12,19,30, 31,35,37	Resistor, 100Ω, 10%, 1/4W	13907
R7,29,34	Resistor, 150Ω, 10%, 1/4W	13909
R8	Resistor, 82kΩ, 10%, 1/4W	24812
R9,10	Resistor, 2kΩ, 1%, 1/4W	21733
R11	Resistor, 1kΩ, 1%, 1/4W	21730
R13	Resistor, 100Ω, 1%, 1/4W	21720
R14,17,22	Resistor, 6.8kΩ, 10%, 1/4W	13930
R15,16	Resistor, 68Ω, 10%, 1/4W	13902
R18,21,23,33	Resistor, 1kΩ, 10%, 1/4W	13920
R20,28,36	Resistor, 220Ω, 10%, 1/4W	13911
R24,27	Resistor, 5.6kΩ, 10%, 1/4W	13891
R25,26	Resistor, 10Ω, 10%, 1/4W	13895
R32	Resistor, 3.3kΩ, 10%, 1/4W	13926
Q1,3,8-15	Transistor, 2N3904	18751
Q2,6,7	Transistor, 2N3906	18754
Q4	Transistor, 2N3053	12232
Q5	Transistor, 2N4037	13590
T1	Transformer, Coax, 20T	42871
T2	Transformer, 40T, 2 Strand	42869

NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μf UNLESS OTHERWISE STATED.
3. ALL WAVEFORMS ARE MEASURED WITH AN UNKNOWN OF 160pf, ON THE 200pf RANGE AT HIGH VOLTAGE, AND ARE APPROXIMATELY CORRECT.



TRANSISTOR	FERRITE BEAD
Q11	L5
Q13	L4
Q14	L7
Q12	L6

TEST POINT NV
NO SIGNAL

0V
-.1V
-.2V
-.3V

TEST POINT SV
1MHZ SIGNAL
2.9V P-P

TYPICAL K1 & K2

Figure 5-11. Circuit Assembly, Null, Part No. 41360

5.13 CIRCUIT ASSEMBLY, STANDARD (Part No. 41324)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 25pF, 1kV, Disc	Ø1924
C2,3,11,12	Capacitor, 22µF, 15V, Tant	18852
C4	Capacitor, Ø.Ø15µF, 6ØØV, 1Ø%	42936
C5	Capacitor, Ø.Ø33µF, 2ØØV	26Ø97
C6-1Ø,17	Capacitor, Ø.Ø5µF, 5ØV, Disc	12116
C13	Capacitor, 5ØØpF, 1kV, Disc	Ø192Ø
C14	Capacitor, 1pF, ±Ø.5pF, Mica	43281
C15	Capacitor, 1ØpF, 5%, MNica	42934
C16	Capacitor, 1ØØpF, 1% Mica	Ø1933
CR1-4	Diode, 1N914A	12356
K1,2	Relay, GB822A-2	26667
K3	Relay, GB835C-2	27776
L1,3-6	Inductor, 1mH	43163
L2	Inductor, 2ØT, Coil	42872
R1,35,45,48	Resistor, 1ØØΩ, 1Ø%, 1/4W	13Ø7
R2,9,39,44,47	Resistor, 15ØΩ, 1Ø%, 1/4W	13Ø9
R3	Resistor, 316Ω, 1%, 1/4W	21725
R4	Resistor, 22ØΩ,1Ø%, 1/4W	13911
R5,6,8,4Ø,41,43,49	Resistor, 1kΩ, 1Ø%, 1/4W	1392Ø
R7,13,16,42	Resistor, 6.8kΩ, 1Ø%, 1/4W	1393Ø
R1Ø	Resistor, 1MΩ, 1Ø%, 1/4W	1396Ø
R11,12	Resistor, 1ØkΩ, 1Ø%, 1/4W	13933
R14,15,37	Resistor, 68Ω, 1Ø%, 1/4W	1392
R17	Resistor, 1ØØΩ, 1%, 1/4W	2172Ø
R18	Resistor, 3.3Ω, 1Ø%, 1/4W	13888
R19,2Ø	Resistor, 1kΩ, 1%, 1/4W	2173Ø
R21,22,27,28,33,34	Resistor, 2kΩ, Trimpot	12Ø84
R23	Resistor, 634Ω, 1%, 1/4W	21728
R24	Resistor, 499Ω, 1%, 1/4W	21727
R25,26	Resistor, 1Ø kΩ, 1%, 1/4W	2174Ø
R29,3Ø	Resistor, 5.11kΩ, 1%, 1/4W	25998
R31,32	Resistor, 1ØØkΩ, 1%, 1/4W	2175Ø
R36	Resistor, 1ØΩ, 1Ø%, 1/4W	13895
R38	Resistor, 3.3kΩ, 1Ø%, 1/4W	13926
R46	Resistor, 47ØΩ, 1Ø%, 1/4W	13915
T1	Transformer, Coax, 2ØT	42871
T2	Transformer, 2ØT, 6 Strand	4287Ø
Q1,3,4,5,9,1Ø,13	Transistor, 2N3Ø4	1875l
Q2,6,7,8,11,12, 14,15	Transistor, 2N3Ø6	18754
W1-7	Wire	Ø6Ø91

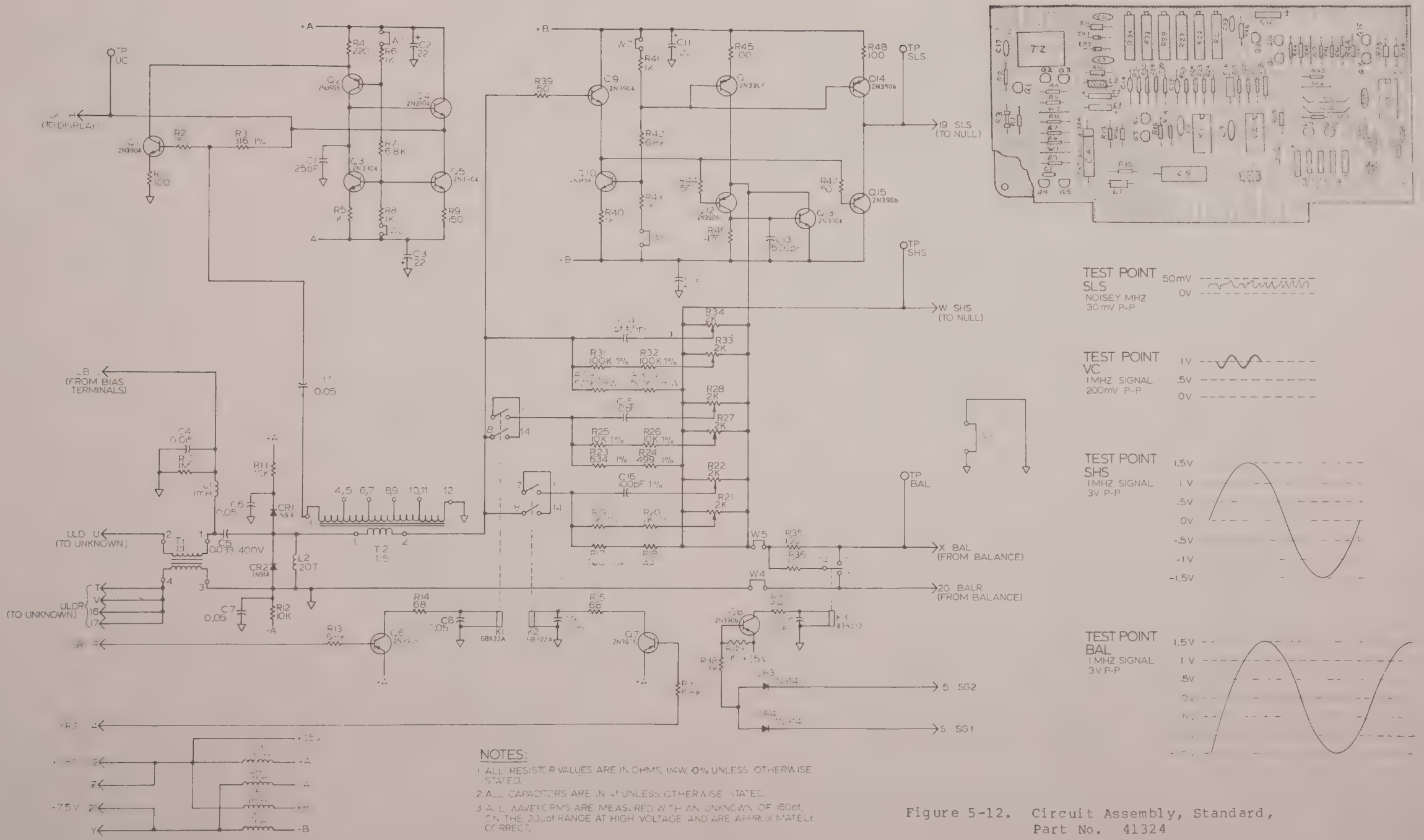
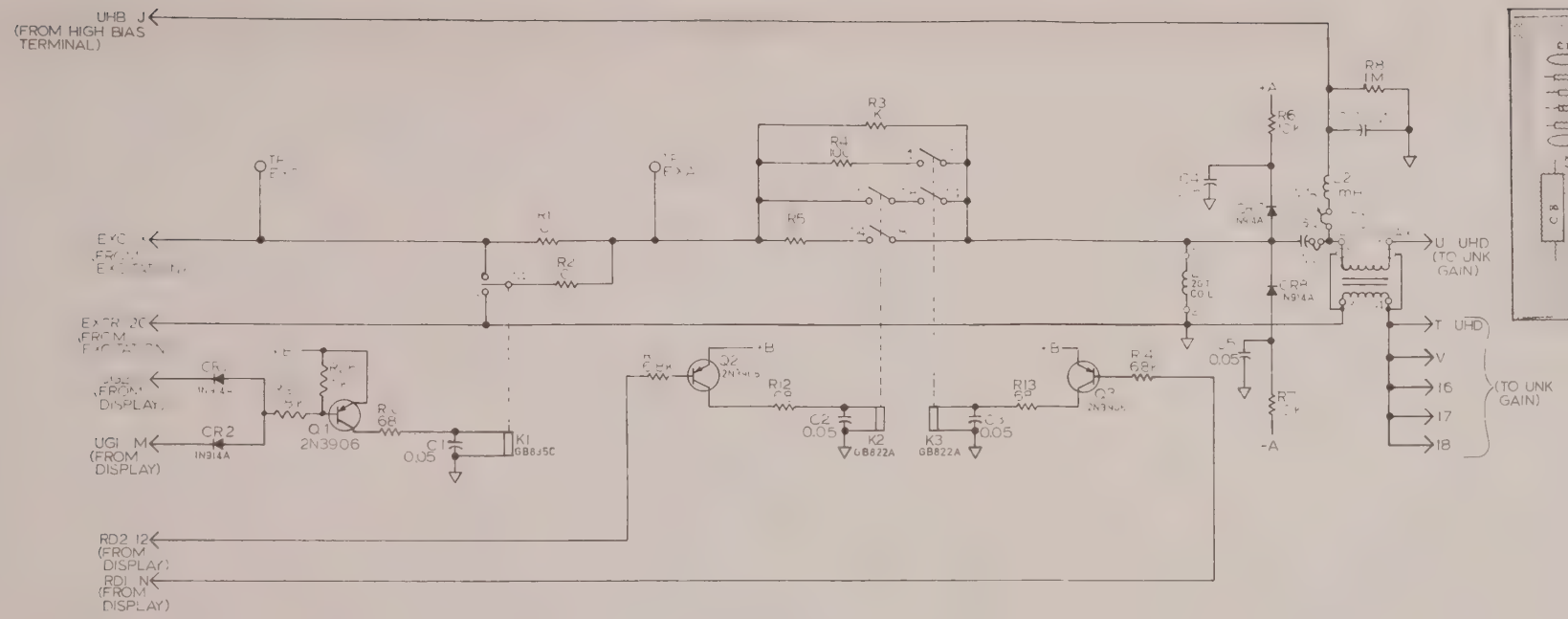
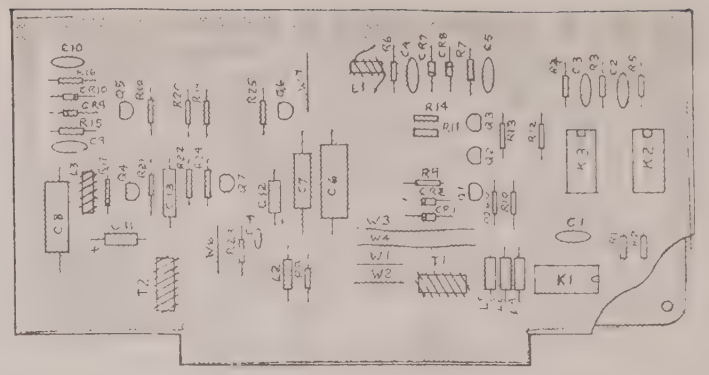


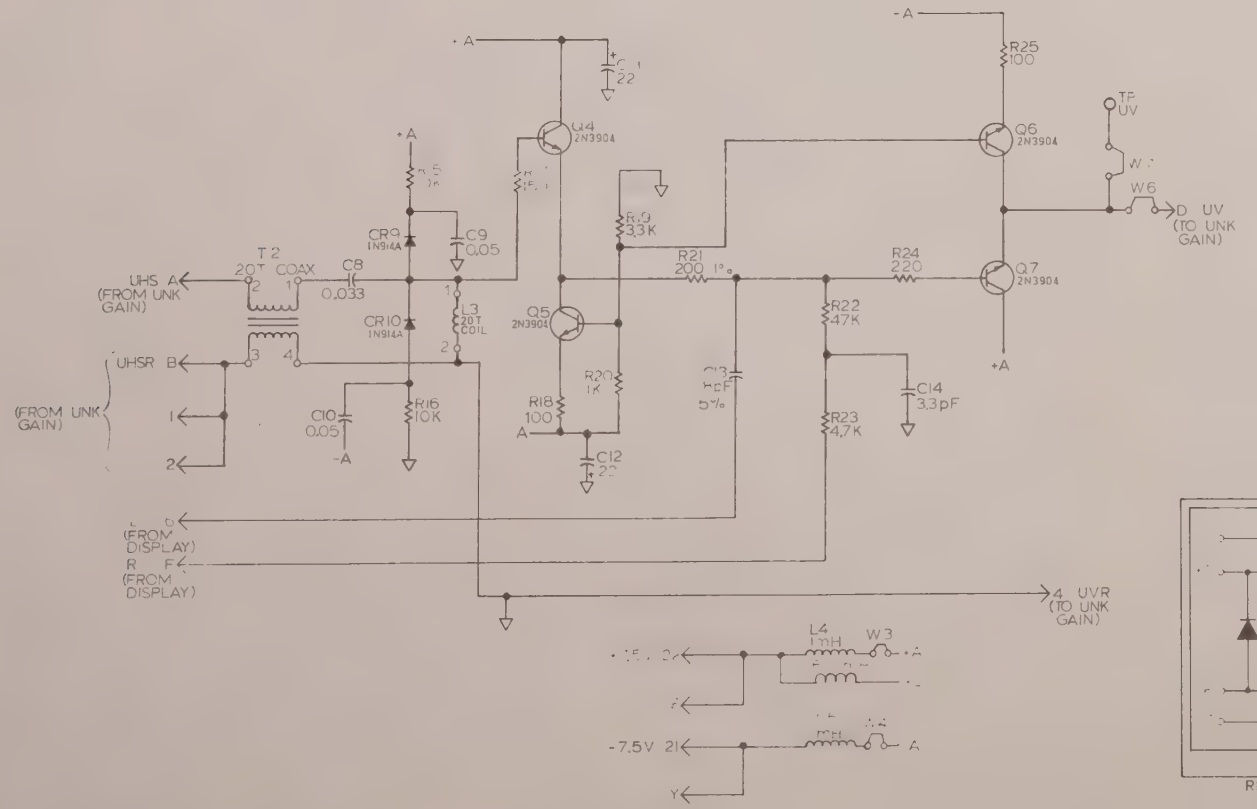
Figure 5-12. Circuit Assembly, Standard, Part No. 41324

5.14 CIRCUIT ASSEMBLY, BALANCE (Part No. 40663)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,2,6,7,10,13 18,19,21,22	Capacitor, 0.05µF, 50V, Disc	12116
C8,9,11,12,15,17	Capacitor, 0.01µF, 50V, Disc	12144
C3	Capacitor, 500pF, 50V, Disc	12043
C4	Capacitor, 100pF, 50V, Disc	12241
C5,20,26,27	Capacitor, 22µF, 15V, Tant	18852
C14,16	Capacitor, 0.02µF, 100V, Disc	12115
C23	Capacitor, 50pF, 1%, Mica	01932
C24,25	Capacitor, 8pF, Disc	02127
C28	Capacitor, 18pF, 5% Mica	02130
CR1,2	Diode, 1N914A	12356
L1-6	Inductor, 1mH	43163
Q1-6	Transistor, 2N3904	18751
Q7,8	Transistor, 2N3906	18754
Q9,10	Transistor, 2N3053	12232
U1,2,5,6	IC, MC1495L	43127
U3,4	IC, 741K	21625
R1,2,10,15-18,23 27-30,35,43-46, 51-54,64,65	Resistor, 150Ω, 10%, 1/4W	13909
R3,4,11	Resistor, 22Ω, 10%, 1/4W	12455
R6,7,50,58	Resistor, 680Ω, 10%, 1/4W	13917
R8	Resistor, 3.3kΩ, 10%, 1/4W	13926
R9,12,67	Resistor, 1kΩ, 10%, 1/4W	13920
R13,14	Resistor, 470Ω, 10%, 1/4W	13915
R19,20,31,32,63	Resistor, 15kΩ, 10%, 1/4W	13935
R21,24,33,36	Resistor, 2kΩ, 1%, 1/4W	21733
R22,34	Resistor, 2kΩ, Trimpot	12084
R25,37,47,48,55,56	Resistor, 4.7kΩ, 10%, 1/4W	13927
R26,38,49,57	Resistor, 2.2kΩ, 10%, 1/4W	13924
R39-42	Resistor, 100Ω, 10%, 1/4W	13907
R59,68	Resistor, 47Ω, 10%, 1/4W	13901
R61	Resistor, 6.8kΩ, 10%, 1/4W	13930
R62	Resistor, 10kΩ, 10%, 1/4W	13933
R66	Resistor, 150Ω, 10%, 1W	12171
T1	Transformer, 13T, 2 Strand	42873
T2	Transformer, 20T, 4 Strand	42874

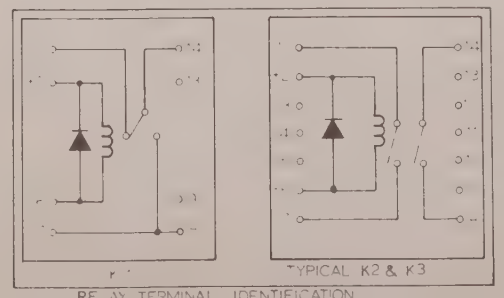






NOTES:

1. WAVE FORMS SHOWN ARE FOR AN "UNKNOWN" OF 160pF, MEASURED AT HIGH VOLTAGE AND ARE APPROXIMATELY CORRECT.
2. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10 % UNLESS OTHERWISE STATED.
3. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.



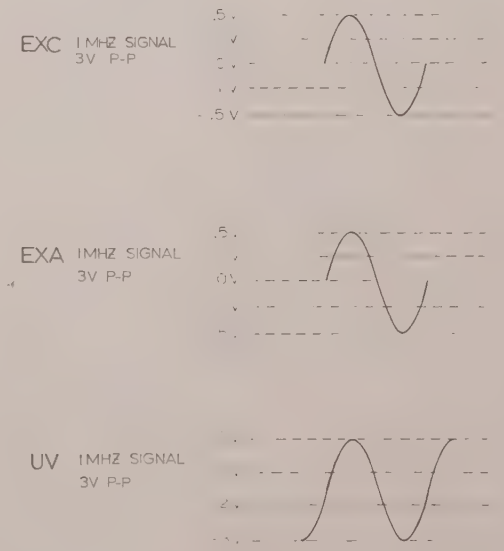
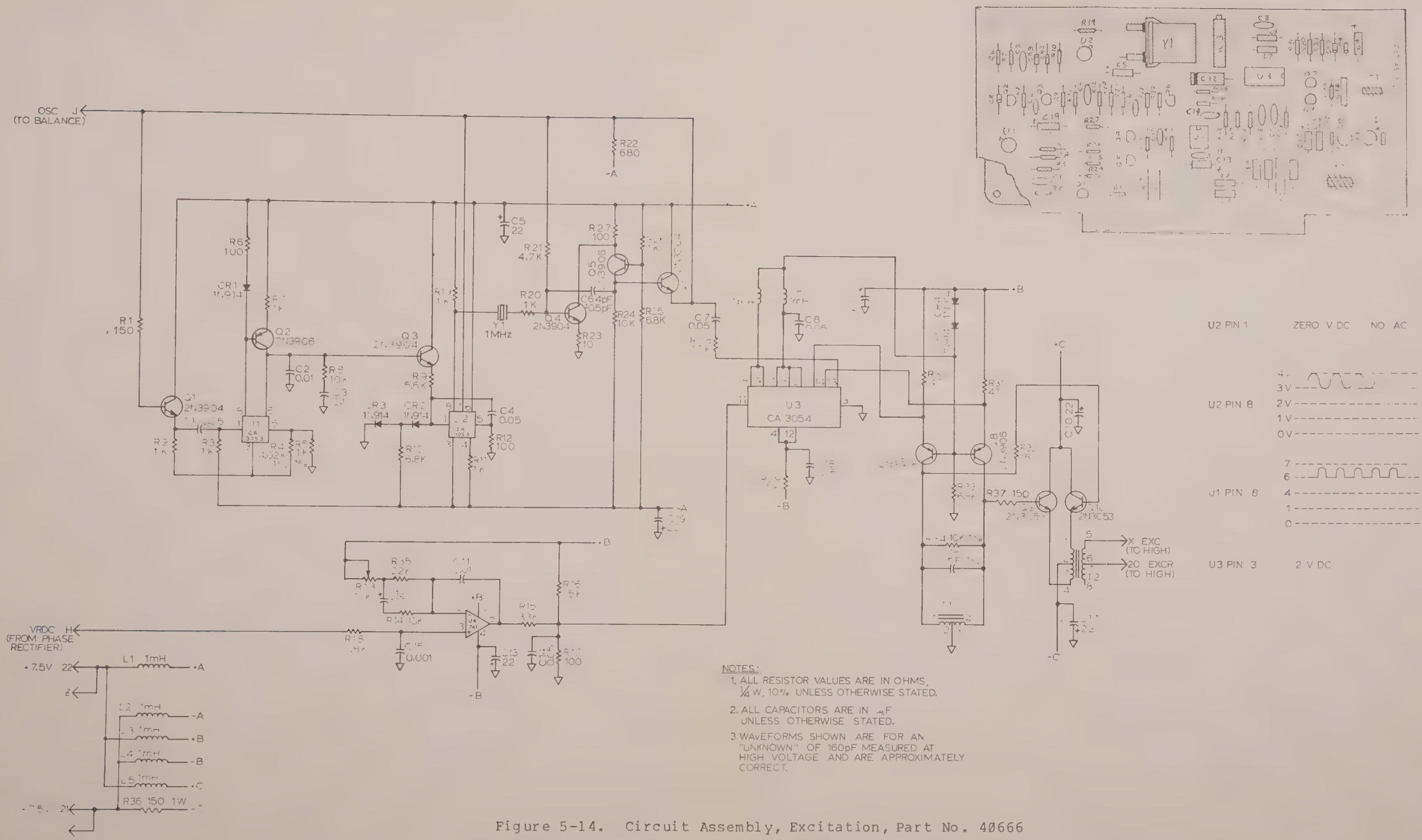


Figure 5-14. Circuit Assembly, High, Part No. 41322

5.16 CIRCUIT ASSEMBLY, EXCITATION (Part No. 40666)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,4,7,8,14,18	Capacitor, Ø.Ø5µF, 5ØV, Disc	12116
C2,11	Capacitor, Ø.Ø1µF, 5ØV, Disc	12144
C3	Capacitor, 0.1µF, 1ØØV, Disc	24395
C5,9,1Ø,13,17,19	Capacitor, 22µF, 15V, Tant	18852
C15	Capacitor, Ø.ØØ1µF, 1kV, Disc	21215
C16	Capacitor, 1ØØpF, 1%, Mica	Ø1933
C6	Capacitor, 4pF, ±Ø.5pF, Mica	Ø2126
C12	Capacitor, 1ØØµF, 12V	Ø6157
CR1-5	Diode 1N914A	12356
L1-8	Inductor, 1mH	43163
Q1,3,4,6	Transistor, 2N3ØØ4	18751
Q2,5,7,8	Transistor, 2N3ØØ6	18754
Q9,1Ø	Transistor, 2N3Ø53	12232
R1,32,37	Resistor, 15Ø Ω, 1Ø%, 1/4W	13ØØ9
R2,3,7,11,19, 2Ø,26,29	Resistor, 1kΩ, 1Ø%, 1/4W	13ØØ2Ø
R4	Resistor, 4.Ø2kΩ, 1%, 1/4W	21736
R6,12,17,27	Resistor, 1ØØΩ, 1Ø%, 1/4W	13ØØ7
R8,14,24,28	Resistor, 1ØkΩ, 1Ø%, 1/4W	13933
R9	Resistor, 5.6kΩ, 1Ø%, 1/4W	13928
R1Ø,18,25,33	Resistor, 6.8kΩ, 1Ø%, 1/4W	13ØØ3Ø
R21	Resistor, 4.7kΩ, 1Ø%, 1/4W	13927
R23	Resistor, 1ØΩ, 1Ø%, 1/4W	13895
R22	Resistor, 68ØΩ, 1Ø%, 1/4W	13917
R35	Resistor, 22kΩ, 1Ø%, 1/4W	13937
R15	Resistor, 3.3kΩ, 1Ø%, 1/4W	13926
R16	Resistor, 15kΩ, 1Ø%, 1/4W	13935
R3Ø,31	Resistor, 47Ω, 1Ø%, 1/4W	13ØØ1
R34	Resistor, 1ØkΩ, 1%, 1/4W	21ØØ4Ø
R36	Resistor, 15ØΩ, 1Ø%, 1W	12171
R5	Resistor, 1kΩ, 1%, 1/4W	21ØØ3Ø
R13	Resistor, 1ØkΩ, Trimpot	2Ø145
T1	Transformer, 13T, 2 Strand	42873
T2	Transformer, 2ØT, 4 Strand	42874
U1,2	IC, CA3Ø53	43164
U4	IC, 741K Special	21625
U3	IC, CA3Ø54	43136
Y1	Crystal, 1MHz	2Ø932
W1,2	Wire	Ø6Ø91
	Socket, Crystal Holder	24444



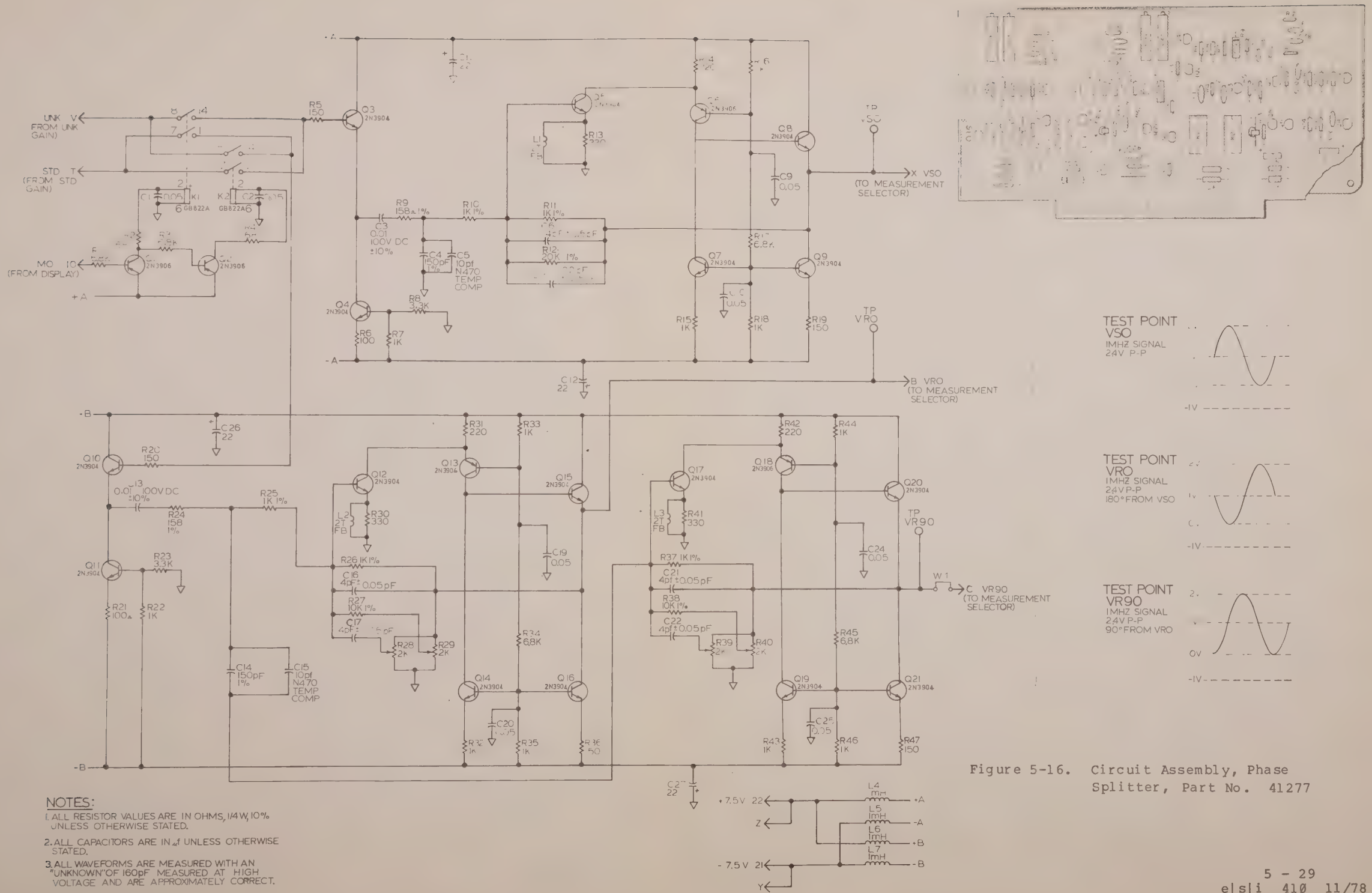
NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, ¼ W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.
3. WAVEFORMS SHOWN ARE FOR AN "UNKNOWN" OF 160pF MEASURED AT HIGH VOLTAGE AND ARE APPROXIMATELY CORRECT.

Figure 5-14. Circuit Assembly, Excitation, Part No. 40666

5.17 CIRCUIT ASSEMBLY, PHASE SPLITTER (Part No. 41277)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,2,9,10,19,20 24,25	Capacitor, Ø.Ø5µF, 5ØV, Disc	12116
C3,13	Capacitor, Ø.Ø1µF, ±1Ø%, 1ØØV	12260
C4,14	Capacitor, 15ØpF, 1%, 5ØØV, Mica	43131
C5,15	Capacitor, 1ØpF, 1ØØØV Temp. Comp.	43133
C6,16,17,21,22	Capacitor, 4pF, ±Ø.5pF	Ø2126
C11,12,26,27	Capacitor, 22µF, 15V, Tant	18852
C28	Capacitor, 2.2pF, ±Ø.5pF	Ø9Ø63
K1,2	Relay, GB822A-2	26667
L1-3	Inductor, 2T, Large Ferrite Bead	43167
L4-7	Inductor, 1mH	43163
Q1,2,6,13,18	Transistor, 2N3ØØ6	18754
Q3-5,7-12,14-17, 19-21	Transistor, 2N3Ø4	18751
R1,3,17,34,45	Resistor, 6.8kΩ, 1Ø%, 1/4W	13930
R2,4	Resistor, 68Ω, 1Ø%, 1/4W	13902
R5,19,2Ø,36,47	Resistor, 15ØΩ, 1Ø%, 1/4W	13909
R6,21	Resistor, 1ØØΩ, 1Ø%, 1/4W	13907
R8,23	Resistor, 3.3kΩ, 1Ø%, 1/4W	13926
R9,24	Resistor, 158Ω, 1%, 1/4W	12722
R1Ø,11,25,26,37	Resistor, 1kΩ, 1%, 1/4W	21730
R12	Resistor, 2ØkΩ, 1%, 1/4W	21743
R13,3Ø,41	Resistor, 33ØΩ, 1Ø%, 1/4W	13913
R15,16,18,22,32,33 35,43,44,46,47	Resistor, 1kΩ, 1Ø%, 1/4W	13920
R27,38	Resistor, 1ØkΩ, 1%, 1/4W	21740
R28,29,39,4Ø	Resistor, 2kΩ, Trimpot	12Ø84
W1	Wire	Ø6Ø91



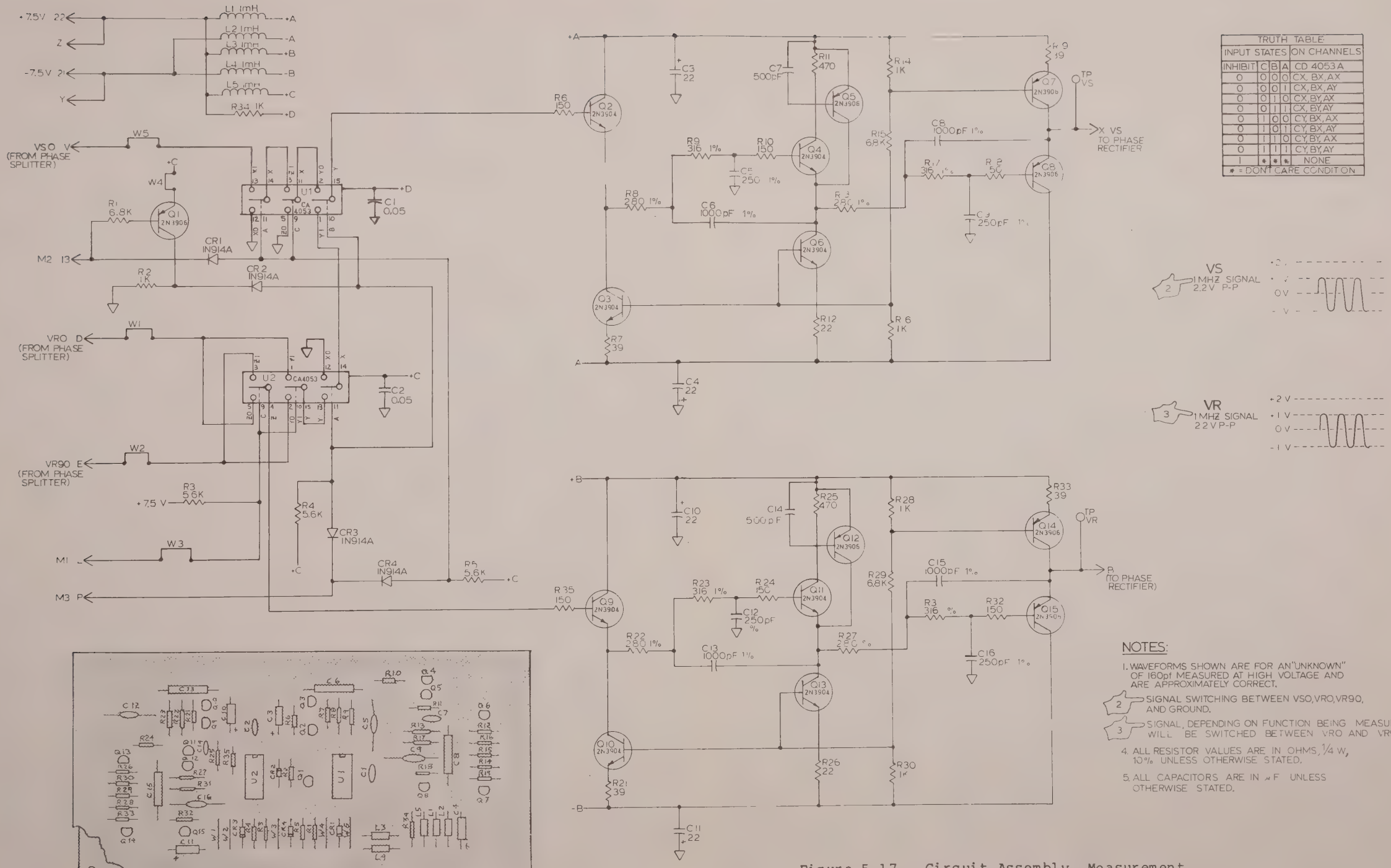
NOTES:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μf UNLESS OTHERWISE STATED.
3. ALL WAVEFORMS ARE MEASURED WITH AN "UNKNOWN" OF 160pF MEASURED AT HIGH VOLTAGE AND ARE APPROXIMATELY CORRECT.

Figure 5-16. Circuit Assembly, Phase Splitter, Part No. 41277

5.18 CIRCUIT ASSEMBLY, MEASUREMENT SELECTOR (Part No. 42395)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,2	Capacitor, Ø.Ø5µF, 5ØV, Disc	12116
C3,4,1Ø,11	Capacitorm 22µF, 15V, Tant	18852
C5,16,9,12	Capacitor, 25ØpF, 1%, 5ØØV, Mica	43129
C6,8,13,15	Capacitor, 1ØØØpF, 1%, 5ØØV, Mica	Ø1931
C7,14	Capacitor, 5ØØpF, 1kV, Disc	Ø192Ø
CR1-4	Diode, 1N914A	12356
U1,2	Relay, CD4Ø53	2Ø744
L1-5	Inductor, 1mH	43163
Q1,5,7,8,12, 14,15	Transistor, 2N39Ø6	18754
Q2-4,6,9,1Ø 11,13	Transistor, 2N39Ø4	18751
R1,15,29	Resistor, 6.8kΩ, 1Ø%, 1/4W	1393Ø
R2,14,16,28, 3Ø,34	Resistor, 1kΩ, 1Ø%, 1/4W	1392Ø
R3,4,5	Resistor, 5.6kΩ, 1Ø%, 1/4W	13928
R6,1Ø,18,24, 32,35	Resistor, 15ØΩ, 1Ø%, 1/4W	1393Ø
R7, 21,19,33	Resistor, 39Ω, 1Ø%, 1/4W	21219
R8, 13,22,27	Resistor, 28ØΩ, 1%, 1/4W	21766
R9, 17,31,23	Resistor, 316Ω, 1%, 1/4W	21725
R11,25	Resistor, 47ØΩ, 1Ø%, 1/4W	13915
R12,26	Resistor, 22Ω, 1Ø%, 1/4W	12455
W1-5	Wire	Ø6Ø91



TRUTH TABLE				
INPUT STATES				ON CHANNELS
INHIBIT	C	B	A	CD 4053 A
0	0	0	0	CX, BX, AX
0	0	0	1	CX, BX, AY
0	0	1	0	CX, BY, AX
0	0	1	1	CX, BY, AY
0	1	0	0	CY, BX, AX
0	1	0	1	CY, BX, AY
0	1	1	0	CY, BY, AX
0	1	1	1	CY, BY, AY
1	*	*	*	NONE

* = DON'T CARE CONDITION

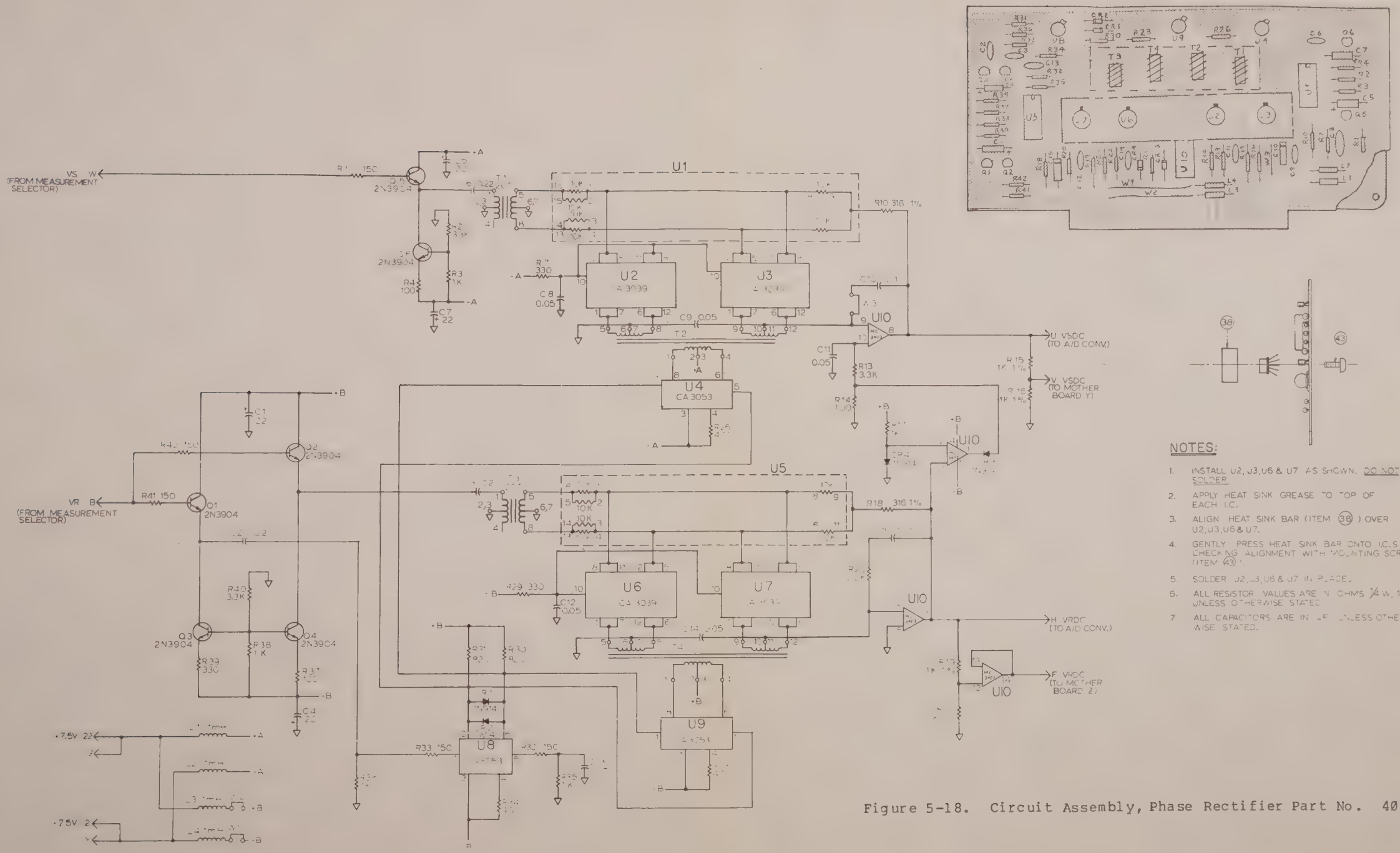
NOTES:

1. WAVEFORMS SHOWN ARE FOR AN "UNKNOWN" OF 160pf MEASURED AT HIGH VOLTAGE AND ARE APPROXIMATELY CORRECT.
2. SIGNAL SWITCHING BETWEEN VSO, VRO, VR90, AND GROUND.
3. SIGNAL, DEPENDING ON FUNCTION BEING MEASURED, WILL BE SWITCHED BETWEEN VRO AND VR90.
4. ALL RESISTOR VALUES ARE IN OHMS, 1/4 W, 10% UNLESS OTHERWISE STATED.
5. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.

Figure 5-17. Circuit Assembly, Measurement Selector, Part No. 42395

5.19 CIRCUIT ASSEMBLY, PHASE RECTIFIER (Part No. 40668)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1,4,5,7	Capacitor, 22µF, 15V, Tant	18852
C2,3,6	Capacitor, Ø.22µF, 5ØV, Disc	13680
C8,9,11,12-14	Capacitor, Ø.Ø5µF, 5ØV, Disc	12116
C1Ø,15	Capacitor, Ø.Ø1µF, ±1Ø%, 1ØØV	12260
CR1-4	Diode, 1N914A	12356
L1-4	Inductor, 1mH	43163
Q1-6	Transistor, 2N39Ø4	18751
R1,32,33,41,42	Resistor, 15ØΩ, 1Ø%, 1/4W	13909
R2,13,4Ø	Resistor, 3.3kΩ, 1Ø%, 1/4W	13926
R4,14,37	Resistor, 1ØØΩ, 1Ø%, 1/4W	13907
R3,17,35,36,38	Resistor, 1kΩ, 1Ø%, 1/4W	13920
R7,29,39	Resistor, 33ØΩ, 1Ø%, 1/4W	13913
R1Ø,18	Resistor, 316Ω, 1%, 1/4W	21725
R15,16,19,22	Resistor, 1kΩ, 1%, 1/4W	21730
R2Ø	Resistor, 2.2kΩ, 1Ø%, 1/4W	13924
R23,26,34	Resistor, 47Ø, 1Ø%, 1/4W	13915
R3Ø,31	Resistor, 82ØΩ, 1Ø%, 1/4W	13919
T1,3	Transformer, 2ØT, 4 Strand	42874
T2,4	Transformer, 2ØT, 6 Strand	42870
U1,5	Resistor, 1Økω, Ø.5%, Resistor Network	43077
U2,3,6,7	IC, CA3Ø39	43126
U4,8,9	IC, CA3Ø53	43164
U1Ø	IC, MC34Ø3	4Ø84Ø
W1-3	Wire	Ø6Ø91
	Temp Equalizer	43169
	Transformer Temp Shield	43170



NOTES:

1. INSTALL U2, U3, U6 & U7 AS SHOWN. DO NOT SOLDER.
2. APPLY HEAT SINK GREASE TO TOP OF EACH I.C.
3. ALIGN HEAT SINK BAR (ITEM (38)) OVER U2, U3, U6 & U7.
4. GENTLY PRESS HEAT SINK BAR ONTO I.C.S CHECKING ALIGNMENT WITH MOUNTING SCREW (ITEM (43)).
5. SOLDER U2, U3, U6 & U7 IN PLACE.
6. ALL RESISTOR VALUES ARE IN OHMS ¼ W, 10% UNLESS OTHERWISE STATED.
7. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.

Figure 5-18. Circuit Assembly, Phase Rectifier Part No. 40668

APPENDIX A

OPTIONS OPERATION

A.1 INTRODUCTION

Options for Model 296, 296V and 410 LRC meters are plug-in circuit assemblies. Three sites are available for options in the 296 and 296V and only two are available in the Model 410 (see Table A-1). One option from each group can be plugged in at a time and can be plugged into only the one site assigned. Refer to Figure A-1 for location of options.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING OPTIONS.

OPTIONS GROUP	OPTION*		
	MODEL 296	MODEL 296V	MODEL 410
AUXILIARY FUNCTIONS GROUP	HIGH SPEED MEASUREMENT DC RESISTANCE MEASUREMENT		
AUXILIARY OUTPUT GROUP	HANDLER INTERFACE	HANDLER INTERFACE	HANDLER INTERFACE
REMOTE PROGRAMMING GROUP	GPIB CARD READER INTERFACE TELETYPE INTERFACE	GPIB CARD READER INTERFACE TELETYPE INTERFACE	GPIB CARD READER INTERFACE TELETYPE INTERFACE

*Only one option from each group allowed at one time.

Table A-1.

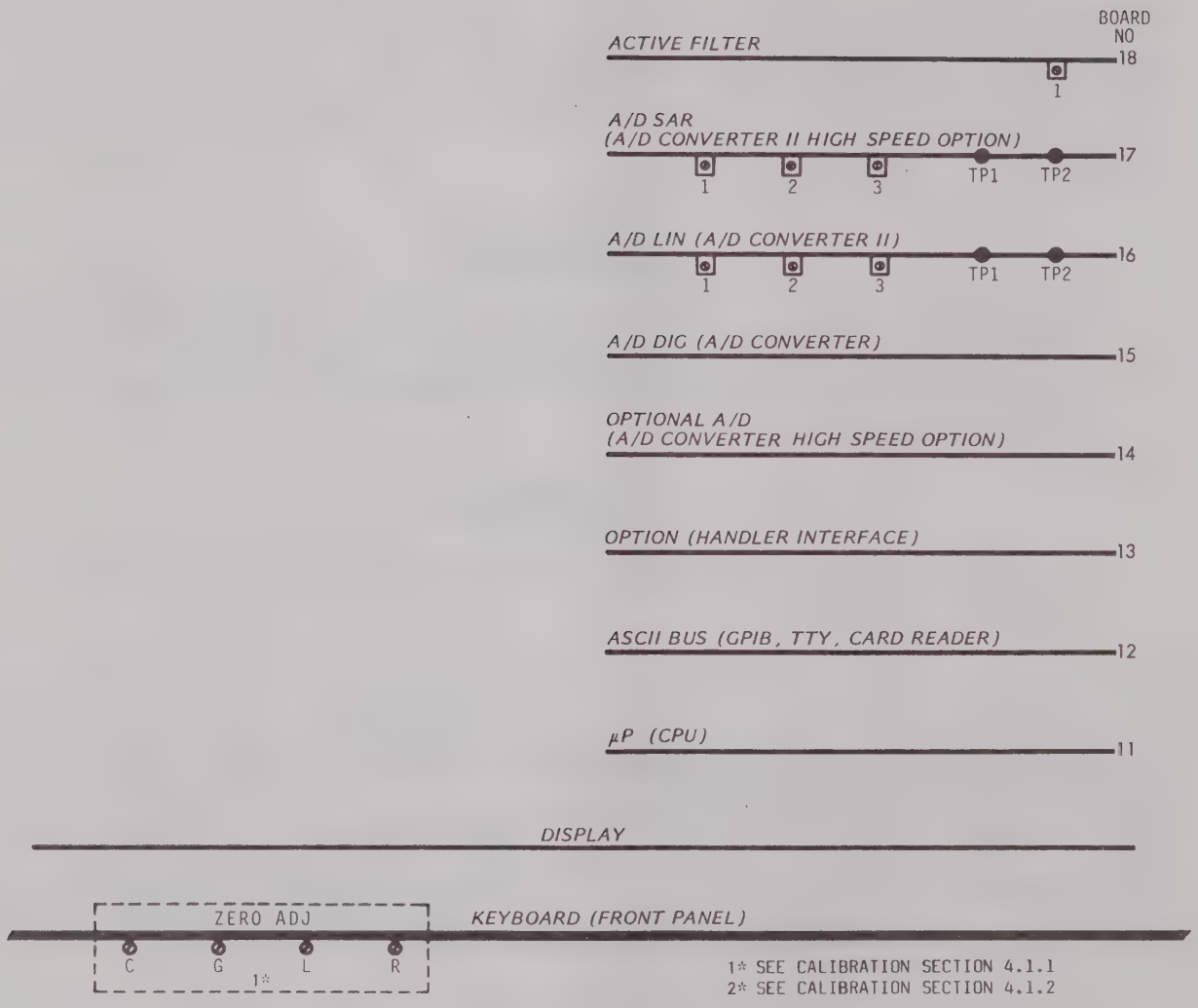


Figure A-1. Option Locations

A.2 REMOTE PROGRAMMING AND INTERFACE OPTIONS OPERATION

Table A-2 gives programming commands for the GPIB, teletype and card reader interface options. With any of these interfaces installed, Model 296, 296V and 410 LRC meters may be programmed in the same manner as from the front panel.

The remote programming function characters listed in Table A-2 must be transmitted to LRC meter only when a mode change is desired. Functions remain in effect until another function is transmitted or power turned off.

An X (red button) must precede each red button function just as for manual programming. An exception is when programming a range multiplier such as µF or mΩ. In this case only one X is required.

Output commands are very important to remote programming operation. The output commands dictate the method in which LRC meter sends its data to various peripheral devices. They must be a part of the programming command string. When addressed to TALK by the GPIB interface or receiving a TALK command (') through the TTY interface one of the following commands must be used:

) Output when addressed to TALK (or commanded to output information). This immediately outputs both displays. It is useful for examining functions entered such as nominal values, settling time, band limits, etc.

* Outputs data when addressed after a measurement is complete. Also sets SRO line low to indicate end of measurement. It is useful when an external device is initiating single measurements and needs output data upon completion of measurement.

Two other output commands are available:

[Output when measurement complete. This command is equivalent to test code 0009. In this mode the LRC meter outputs its data immediately after a measurement is completed. No TALK command need be sent. It is useful when the controlling device (such as a TTY or printer) requires output data after measurement without having to send a TALK command. This command is not recommended for IEEE Bus use because data usually cannot be handled until requested. It can be used to continuously output results of a changing measured value such as encountered in a temperature test.

] Cancels [so that output is again available only when addressed or commanded to TALK.

ASCII CHARACTERS for GPIB (IEEE 488), TTY (SERIAL) and CARD READER																			
TTY (SERIAL) AND CARD READER / GPIB (IEEE 488)	ASCII CHARACTER	KEYBOARD FUNCTIONS				HOLLERITH TO ASCII												ASCII CHARACTER[3]	
		MODELS 296 and 296V		MODEL 410															
		WHITE	RED[1]	WHITE	RED[1]	9	8	7	6	5	4	3	2	1	0	-	&	■	■■■
	F	HI FREQ	LO FREQ	HI VOLTAGE	B/X				■								■	F	
	9 or O	9	Ω	9	Ω	■			■■■							■■■		9	O
	8 or L	8	H	8	H		■					■■■				■■■		8	L
	7 or C	7	F	7	F			■				■■■					■■■	7	C
	T	T	S	T	S							■			■			T	
	R	RANGE	DC OHMS 296 ONLY	RANGE	D Correction	■										■		R	
	V	HI VOLTAGE	LO VOLTAGE	MED VOLTAGE	LO VOLTAGE					■					■			V	
	6 or Q	6	Q	6	Q		■■■		■							■■■		6	Q
	5 or D	5	D	5	D					■	■■■						■■■	5	D
	4 or $	4	$	4	$		■■■				■■■				■■■			4	$
	A or ↑	↑	AUTO	↑	AUTO									■			■	A	
	=	NOM VALUE	Δ	NOM VALUE	Δ		■		■								■	=	
	E	PRL EQUIV CKT	SER EQUIV CKT	PRL EQUIV CKT	SER EQUIV CKT					■							■	E	
	3 or M	3	M	3	M						■■■	■				■■■		3	M
	2 or K	2	k	2	k								■					2	K
	1	1	m	1	m									■				1	
	H or ←	↓	HOLD	↓	HOLD		■										■	H	
	B	SET POINT		SET POINT									■				■	B	
	G	START	SINGLE	START	SINGLE			■									■	G	
	- or U	-	μ	-	μ						■■■				■■■	■		-	U
	0 or N	0	n	0	n					■■■					■	■■■		0	N
	. or P	.	p	.	p		■	■■■				■				■■■	■	.	P
	X	Red Button	Red Button	Red Button	Red Button			■							■			X	
	S	SETTLING TIME	SECONDS	SETTLING TIME	SECONDS								■		■			S	
	CHARACTER	REMOTE PROGRAMMING FUNCTIONS																	
	)	output when addressed					■			■						■		)	
	*	set service request[3]					■				■					■		*	
	:	lock keyboard and turn on RMT light					■						■					:	
	X:	unlock keyboard and turn off RMT light							program X first then :									X:	
	&	delete all limits data, reset limits counter															■	&	
	X&	reset limits counter							program X first then &									X&	
	[	output when measurement is completed					■						■				■	[	
	]	no output					■						■			■		]	
	'	TALK command for TTY interface					■			■								'	
	\	delete ECHO routine, set ECHO routine					■						■		■			\	

[1] An X must precede each character to obtain red button functions
[2] ■ or ■■■ indicates alternate choices. Example: In line 2 either 9 or O can be used; 9 is set as shown by ■, O is set as shown by ■■■
[3] Output when addressed after measurement complete

Table A-2. Model 296, 296V and 410 Programming Commands for GPIB, TTY and Card Reader Interfaces

The & and X& commands serve an important function when programming limits operation. Each time the SET POINT command is sent (or button pushed) an internal counter is incremented. This counter monitors which set point is to be set next. Since limits must be set from limit 1 up, it is necessary to initialize the counter when setting limits to prevent accidentally programming the wrong limit. An X& command resets the counter so that the next press of the set point returns to number 1 set point, the & command clears all previously set limits and resets the counter. The X& command allows a single limit to be reset without affecting others by programming X& then the number of SET POINT commands necessary to increment the counter to the desired limit. Example: X&BBB - resets then steps to the third limit and is ready to accept a value to store as limit 3.

A.3 GPIB GENERAL PURPOSE INTERFACE BUS OPTION

The GPIB Interface option, ESI Part No. 42404, enables Model 296, 296V and 410 LRC meters to communicate on the bus structure as defined by IEEE 488-1975 specification. The LRC meters will operate in either the TALK or LISTEN mode and uses 7 bit ASCII character format. Table A-2 lists the ASCII characters for functions and operating instructions. All front panel controls and special codes are programmable via the GPIB, including front panel lock-out.

The advantage of GPIB programming is that several instruments can be operated on a common bus with one controller. Each has a unique address which only that instrument recognizes.

A.3.1 Hardware Included

	Part No.
IEEE Interface Circuit Assembly	42132

A.3.2 Installation

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT ASSEMBLIES.

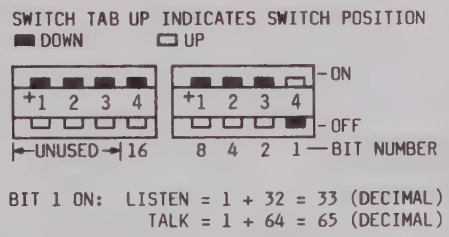
The IEEE circuit assembly is installed by plugging it into the location marked ASCII BUS (12), see Figure A-1.

A.3.3 Operation

Bus addresses for Models 296, 296V and 410 are set at the factory to 65 for TALK and 33 for LISTEN. Addresses may be changed with the switches on the interface PC board. Both TALK and LISTEN addresses are set by the same switch as shown in Figure A-2. TALK address is achieved by adding 64 to the switch setting, LISTEN address by adding 32 to the switch setting. Switches operate in a BCD configuration.

Only the five least significant bits (first five switches from the right) are used to set the address.

The second and third switches from the left should not be changed from their off position. The first switch from the left can be on to enable the LRC meters to transfer data to a printer after measurement is completed. It must be off when LRC meters are used with the IEEE bus. Programming test code 0009 (see Section 2.3.9 of the Model 296 manual) is equivalent to setting the switch ON.



FACTORY SET GPIB ADDRESS

	LISTEN	TALK
DECIMAL	33	65
OCTAL	41	101
ASCII	!	A

Figure A-2.

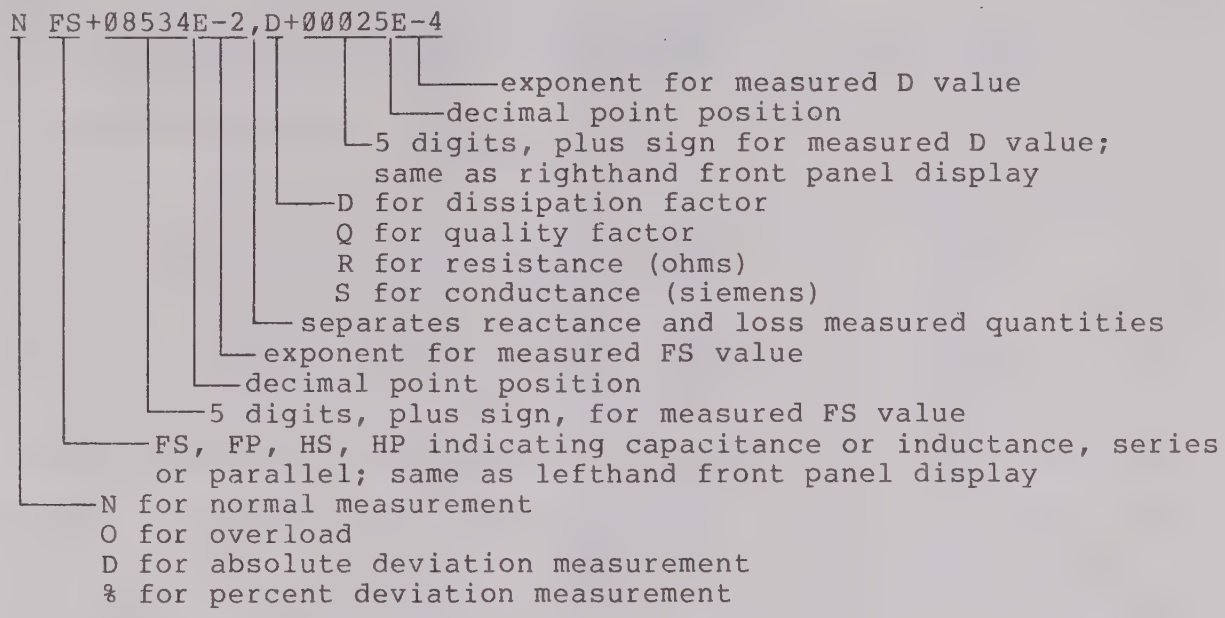
Programming via the GPIB follows the same sequence as programming from the front panel. A typical command string for Model 296 would look like this:

XFR100XUCXEXDXG*

where: XF = low frequency (red button FREQ)
R = range (also puts unit in range hold mode)
100XUC = 100µF
XE = series equivalent circuit
XD = dissipation factor
XV = low voltage
XG = single measurement mode
* = output data after measurement complete when addressed

This string programs the instrument to measure series capacitance on the 100µF range with D as loss function, in the range hold mode, low frequency, low voltage mode, and single measurement mode.

A Model 296V output string for the above example would look like this:


N FS+08534E-2,D+00025E-4
exponent for measured D value
decimal point position
5 digits, plus sign for measured D value; same as righthand front panel display
D for dissipation factor
Q for quality factor
R for resistance (ohms)
S for conductance (siemens)
separates reactance and loss measured quantities
exponent for measured FS value
decimal point position
5 digits, plus sign, for measured FS value
FS, FP, HS, HP indicating capacitance or inductance, series or parallel; same as lefthand front panel display
N for normal measurement
O for overload
D for absolute deviation measurement
% for percent deviation measurement

Measured values are output in floating point format, 5 digits and an exponent. In the example the measured capacitance value is +08534E-2 which represents 8534 x 10^{-2}µF or 85.34µF. Values for capacitance are expressed in µF (microfarads) and values for conductance in µS (microsiemens). Inductance and resistance are expressed in H (henries) and Ω (ohms); µH for 10kHz and 20kHz options. Blank displays are transmitted as ? to indicate that display does not contain data.

An example of Model 296, 296V or 410 operation through the GPIB bus by a Tektronix Graphics Terminal Model 4051 is shown.

100 on SRQ THEN 180	Directs Model 4051 to address 180 when SRQ interrupt is received
110 PRINT "COMMAND";	Operator enters command string for range, etc. Command string must contain an asterisk (*) to assure data acceptance after measurement complete.
120 INPUT A$	Places input command string in 4051 memory location A$.
130 PRINT @ 1:A$	Model 4051 outputs string (stored in location A$) to LRC meter. (LRC meter should at this point be set to desired functions.)
140 for N=1 TO 10	Instructions to perform 10 measurements.
150 PRINT @ 1:XG	4051 commands LRC meter to make a single measurement.

160 WAIT	Stores location 170 as return address after servicing SRQ interrupt. Waits for SRQ interrupt indicating measurement complete. When SRQ is received goes to address 100 for interrupt service instructions.
170 NEXT N	Increments N and returns to address 140 for next measurement.
180 INPUT @ 1:A$	4051 commands LRC meter to send it the measured data (LRC meter TALKS) after the SRQ line has been activated by LRC meter (end of measurement). (Model 4051 stores measured data in memory location A$.) An asterisk (*) must be a part of the command string for data output only after measurement complete.
190 PRINT A$	4051 prints measured data stored in A$.
200 RETURN	Program returns to address 170 (stored by WAIT statement 160).

Results

RUN

COMMAND? R1500XPCX0*	Range 1500pF, series capacitance and resistance. The asterisk is a very important character for this program. It instructs LRC meter to return measurement results only upon completion of the measurement initiated by "XG" (see Table A-2).

```
N FS+15384E-7,R-00001E+2
N FS+15384E-7,R+00000E+2
N FS+15385E-7,R+00000E+2
N FS+15383E-7,R+00000E+2
N FS+15384E-7,R+00000E+2
N FS+15383E-7,R+00001E+2 Measured data.
N FS+15384E-7,R+00000E+2
N FS+15384E-7,R+00000E+2
N FS+15383E-7,R+00000E+2
N FS+15383E-7,R+00000E+2
```

All programming is accomplished via the LRC meter's rear panel REMOTE connector. Table A-3 lists the function for each pin of the REMOTE connector.

Remote Connector Wiring

PCB CONNECTOR	REMOTE CONNECTOR PIN NUMBERS	FUNCTION
5	1	DØ
2	2	D1
1	3	D2
6	4	D3
E	5	EØ1
A	6	DAV
B	7	NRFD
C	8	NDAC
F	9	IFC
D	1Ø	SRQ
J	11	ATN
	12	COM
7	13	D4
3	14	D5
8	15	D6
4	16	D7
H	17	REN

Table A-3. GPIB Option

A.3.4 Calibration

The LRC meters need no adjustment, other than normal calibration, when the GPIB option is installed. The IEEE interface circuit assembly contains no service adjustments.

WARNING

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A.4 TELETYPE INTERFACE OPTION

The Teletype Interface option, ESI Part No. 42735, is used to interface Model 296, 296V and 410 LRC meters to three-wire serial bus systems. With this option installed the LRC meters can interface with:

20mA current loop systems
5V TTL level systems
RS232, ±12V switched at ground systems

A.4.1 Hardware Included

	Part No.
Teletype Interface Circuit Assembly	42763

A.4.2 Installation

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT ASSEMBLIES.

The teletype interface circuit assembly is installed by plugging it into the location marked ASCII BUS (12), see Figure A-1.

A.4.3 Operation

The teletype interface option transmits (TALK) and receives (Listen) serial ASCII data when connected to a TTY, Ø-2ØmA current loop system, 5V TTL level system or RS232, ±12V switched at ground system. The teletype interface circuit assembly outputs data at the proper logic levels to accomodate each of the three systems. The TTY assembly's output is matched to the desired system by placement of wire jumpers, see Table A-4.

	NO JUMPER	W1 INSTALLED	W2 INSTALLED
RS232	—	—	X
TTL	—	X	—
TTY	X	—	—

Table A-4.

NOTE: The correct polarity must be observed when connecting an ASR-33 teletype to the teletype interface option.

With no jumper wires installed, the TTY option's output matches 5V TTL level systems (see Table A-4). Installing jumper wire W1 the output matches TTY, Ø-2ØmA current loop systems and jumper wire W2 installed matches to RS232, ±12V switched at ground systems (see Figure A-3).

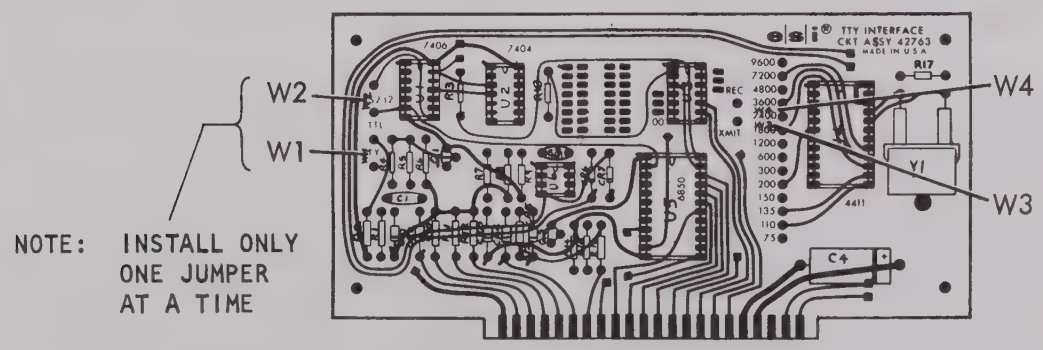
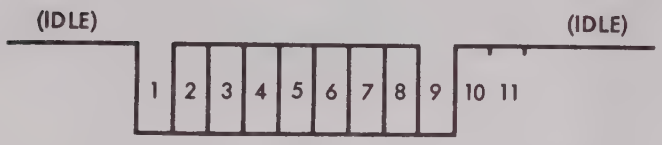


Figure A-3.

The character format is 11 bits (see Figure A-4):

One start bit (1)
Seven data bits (2 thru 8)
Parity bit (no parity) (9)
Two stop bits (10, 11)



	R232	TTL DATA	TTY DATA
HIGH LEVEL (MARK)	-12	+5	20MA
LOW LEVEL (SPACE)	+12	0V	0MA

Figure A-4.

Available baud rates are:

75, 110, 135, 150, 200, 300, 600, 1200,
1800, 2400, 3600, 4800, 7200, 9600

Baud rates are selectable by changing jumper wires W3 and W4 (see Figure A-3). Wire jumper W3 selects the TALK baud rate and W4 selects the LISTEN baud rate.

LISTEN and TALK baud rates are asynchronous. Each can be at different rates than the other. This allows the TTY option to LISTEN using the mode selected by jumper W1 or W2 and to TALK using any of the three modes.

Example: With wire jumper W2 installed, the LISTEN baud rate may be set at 1200 while the TALK baud rate can be set over the entire range.

NOTE: At slow baud rates, the displays may become erratic during the TALK function.

The TALK rate is controlled by the microprocessor and a character is not processed until the preceding character has been transmitted. The end of each TALK sequence is signaled by transmitting a carriage return, a line feed and a null period.

The LISTEN rate is character string dependent. Certain characters require more processing time, so care must be taken not to lose a character by transmitting characters to Model 296, 296V or 410 faster than it can process them. Baud rates above 2400 baud experience this problem and it is recommended to insert a 3ms wait loop between each character.

Optimum transmission speed can be achieved by using the Echo routine. Since the LISTEN data line is buffered and will hold one character, the controller can operate in a handshake mode using the Echo character to initiate transmission of the next character.

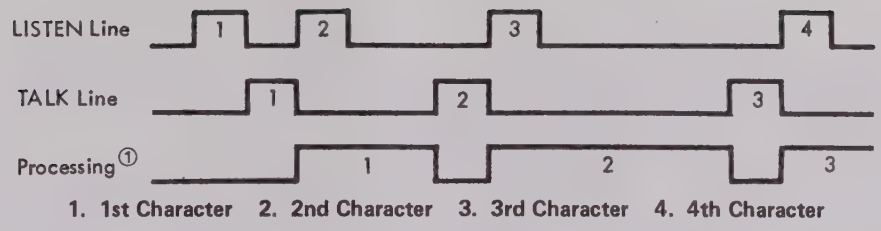


Figure A-5.

Characters are ASCII format and the output string is the same as described in Remote Programming Section A.2. The ' character is the TALK command for the teletype interface. The controller sends a ' when it is ready to receive data. All programming is accomplished via the LRC meter's rear panel REMOTE connector. Table A-5 lists the function of each pin of the REMOTE connector.

Remote Connector Wiring

PCB CONNECTOR	REMOTE CONNECTOR PIN NUMBER	FUNCTION
5	1	+ TTY OUT
2	2	- TTY IN
1	3	+ TTY IN
6	4	- TTY OUT
A	6	DCD
B	7	RTS
F	9	IEE/2
	12	COM
7	13	RS232 IN
3	14	TTL IN
8	15	RS232 OUT
4	16	TTL OUT
H	17	D2

Table A-5. Teletype Interface Option

A.4.4 Calibration

Remote START capability is available with the teletype interface option. To initiate a START measurement, momentarily connect the RST pin of the REMOTE connector to ground.

The LRC meters need no adjustment, other than normal calibration, when the teletype interface option is installed. The teletype interface circuit assembly contains no service adjustments.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

A.5 CARD READER INTERFACE OPTION

The Card Reader Interface option, Part No. 42736 or Part No. 43771, allow Model 296, 296V and 410 LRC meters to be programmed by preprogrammed cards, using a HP11301A Hollerith Card Reader. This simplifies programming, reduces setup time and allows easy, convenient storage of programs. The option consists of a card reader interface PC board and the card reader. The card reader is available either from ESI or Hewlett Packard.

Both options require a CPU circuit assembly exchange. ESI ships CPU circuit assembly Part No. 43826 and invoices an additional $500 which is credited in full upon return of the standard Model 296, 296V or 410 CPU circuit assembly Part No. 41491.

A.5.1 Hardware Included

	Part No.
Option 42736 (Card Reader Interface Kit)	
Card Reader Circuit Assembly	43399
CPU Circuit Assembly	43826
Card Reader to LRC Meter Cable Assembly	43675
HP Punch Cards (200)	43861
Hand Punch	44382
Option 43771	
Card Reader Interface Kit (option)	42736
HP - Manual Card Reader	43776

A.5.2 Installation

WARNING

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CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT ASSEMBLIES.

The Card Reader Interface Assembly is installed by plugging it into the location marked ASCII BUS (12), see Figure A-1. The card reader is connected to the LRC meter's rear panel REMOTE connector via the card reader to LRC meter cable assembly.

A.5.3 Operation

The Card Reader Interface PC Board receives data from the card reader. This data corresponds to the Hollerith code marked on the cards. The Hollerith code input is converted to binary code and compared to binary values pre-stored in a look-up table. When a binary number in the look-up table corresponds to the input binary number an equivalent ASCII code is generated and sent to the microprocessor which controls the instrument.

The recommended card reader is Hewlett Packard 11301A (an HP9870 card reader without a calculator interface). It is a small quiet desk top design with power supplied from Model 296, 296V or 410. It accepts 96 character Hollerith coded cards marked with either a very soft leaded pencil or punched holes (punched holes are recommended to insure the reliable transfer of information).

All programming is accomplished via the LRC meter's rear panel REMOTE connector. Table A-6 lists the function for each pin of the REMOTE connector.

Remote Connector Wiring

PCB CONNECTOR	REMOTE CONNECTOR PIN NUMBER	FUNCTION
5	1	D 7
2	2	D 11
1	3	D Ø
6	4	D 6
E	5	D 1
A	6	CP/MD
B	7	ST/MI
F	9	D 3
	12	COM
7	13	D 8
3	14	D 12
8	15	D 9
4	16	D 4
H	17	D 5

Table A-6. Card Reader Interface Option

Refer to the Card Reader Option instruction manual, Part No. 43981, for further information concerning the card reader and programming Hollerith cards.

A.5.4 Calibration

The LRC meters need no adjustment, other than normal calibration, when the card reader option is installed. The card reader interface circuit assembly contains no service adjustments.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

A.6 HANDLER INTERFACE OPTION

Handler Interface kits enable Model 296, 296V and 410 LRC meters to operate with a mechanical parts handler. The kit accepts a START signal to initiate measurements, provides a BUSY signal which may be used to arrest handler operation during test and offers a contact closure output corresponding to one of ten preselected limit bands (refer to instruction manual for limits operation).

Three standard handler interface kits are available. They are:

ESI Part No. 42436 -- For interfacing the Engineered Automation Auto-Sort Handler to the LRC meter via the ESI Model 1453 Handler Adaptor.

ESI Part No. 44339 -- For interfacing the Daymarc Type 147 and 149 handlers directly to the LRC meter.

ESI Part No. 44340 -- For interfacing Deval handlers to the LRC meter.

Contact the factory for information concerning the use of other part handlers with the Model 296, 296V or 410.

A.6.1 Hardware Included

	Part No.
Handler Interface Kit 42436	
Optional Interface Circuit Assembly	42073
BNC to BNC Cable Assembly (4)	19396
Handler Interface Cable Assembly	44186
Handler Interface Kit 44339	
Optional interface Circuit Assembly	44256
Handler Interface Kit 44340	
Optional Interface Circuit Assembly	44257

A.6.2 Installation

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

CAUTION

TO AVOID DAMAGE TO CIRCUITRY, TURN POWER OFF WHILE PLUGGING IN OR REMOVING CIRCUIT ASSEMBLIES.

The Optional Interface Assembly is plugged into the OPTION location on the LRC meter's right-hand mother board (see Figure A-1).

Installation of the BNC to BNC cable assemblies and the Handler Interface cable assembly, for kit part number 42436, are dependent upon the component handler being used. The BNC cables interconnect the LRC meters HI and LO unknown terminals to the part handler's component contactors. The Handler Interface Cables make all logic connections between the LRC meters rear panel OUTPUTS connector and the component handler.

A.6.3 Operation

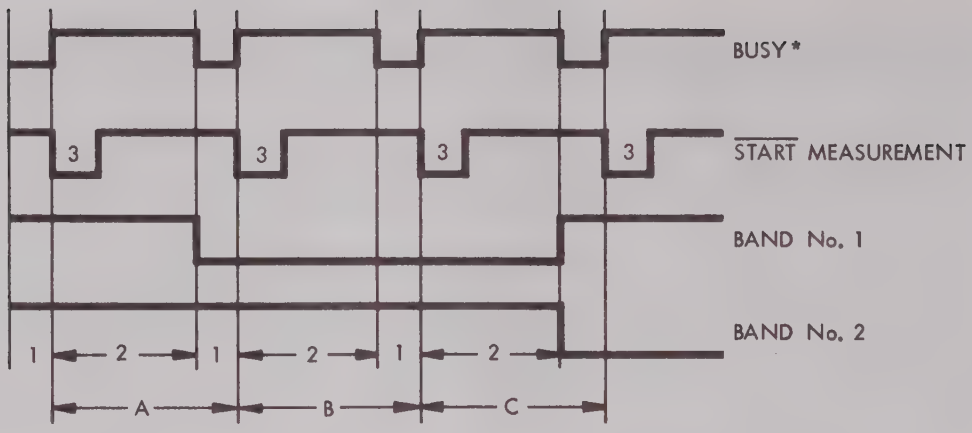
The Optional Interface provides the following functions:

1. START TEST - is the input to an opto-isolator, 4N28. It requires a holding current of 1Ø to 8ØmA to initiate a measurement. A 56ØΩ current limitor resistor is provided for operation from 12V supply.

2. BUSY - is the open collector output of an opto-isolator, 4N28. It is capable of sinking current of typically 16ØmA. This signal can be used to arrest handler operation during test.

3. Output Relays - contact closures that are selected according to preset limits, see LIMITS section of the LRC meter instruction manual. (One relay is closed at a time.) The relays are rated at 1ØØVDC, 25ØmA switching current and 1Ø million operations. Higher currents can be switched with a possible reduction in operation life, especially if contacts arc on opening. Resistive loads are more desirable than inductive loads. For example, a 4ØØmA, 15V, resistive load will not appreciably reduce life. Relays are on sockets for easy replacement.

4. 5V TTL (open collector) Outputs - are available at the rear panel OUTPUTS connector. They require the addition of a jumper wire in place of each output relay.



1. Handler Time -- User dependent.
2. Measurement Time -- Dependent on range and functions. See measurement speed section of the manual.
3. Initiate a measurement signal -- 5ms* minimum.

A. First part was in band No. 1.
B. Second part was also in band No. 1
C. Third part was in band No. 2

* Contact factory for special modifications.

Figure A-6.

All handler interface operations take place via the LRC meter's rear panel OUTPUTS connector. Table A-7 lists the functions for each pin of the OUTPUTS connector.

PCB CONNECTOR	OUTPUTS CONNECTOR PIN NUMBER	FUNCTION
7	1	COMMON
J	2	BAND Ø
H	3	BAND 1
F	4	BAND 2
E	5	BAND 3
D	6	BAND 4
C	7	BAND 5
B	8	BAND 6
A	9	BAND 7
6	1Ø	BAND 8
5	11	BAND 9
2	16	BAND 1Ø
	12	+5V (SYSTEM) OUT
	13	SYSTEM GROUND
8	14	START IN
4	18	BUSY OUT

Table A-7. LRC Meter OUTPUTS Connector Wiring

To assure proper electrical isolation and noise free operation, it is recommended the customer use his common and logic levels when interfacing to the LRC meter. If this is not possible +5V and common are provided at the rear panel OUTPUTS connector (see Table 1) for use by low noise controllers. It is cautioned that excessive noise impressed upon the system +5V supply can disrupt microprocessor operation.

A.6.4 Calibration

The LRC meters need no adjustment, other than normal calibration, when a Handler Interface Kit is installed. The Optional Interface Assembly contains no service adjustments.

WARNING

TO AVOID PERSONAL INJURY FROM ELECTRIC SHOCK DO NOT REMOVE INSTRUMENT COVERS OR PERFORM ANY MAINTENANCE OTHER THAN DESCRIBED IN THIS MANUAL. INSTALLATION AND MAINTENANCE PROCEDURES DESCRIBED IN THIS MANUAL ARE TO BE PERFORMED BY QUALIFIED SERVICE PERSONNEL ONLY.

APPENDIX B

OPTIONS PARTS LISTS AND CIRCUIT ASSEMBLIES

B.1 IEEE Interface Option Circuit Assembly (Part No. 42132)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1, C2	Capacitor, 100µF, 25V	13683
Q1-Q12	Transistor, 2N3904	18751
R1-R5	Resistor, 6.8kΩ, 1/4W Carbon	13930
R6-R8	Resistor, 4.7kΩ, 1/4W, 10%	13927
S1, S2	Switch, SPST, DIP, Rocker	41519
U1, U2	IC, 6820, PIA	41292
U3-U16	IC, MCT6, Optoisolator	24008
U17, U25	Resistor, 1kΩ, DIP	20700
U18	Resistor, 3.3kΩ, DIP	22947
U19	Resistor, 470Ω, DIP	20795
U21	Resistor Network, 470Ω and 3.3kΩ	43000
U22-U24	IC, MC3446, Quad Interface Bus Tran	42704
U26	IC, 7407, TTL Open Coll Hex Inverter	24076
W1-W5	Wire	50203
	Shield, PCB	41469
	Socket, 8 Pin DIP	22410
	Socket, 40 Pin DIP	41342

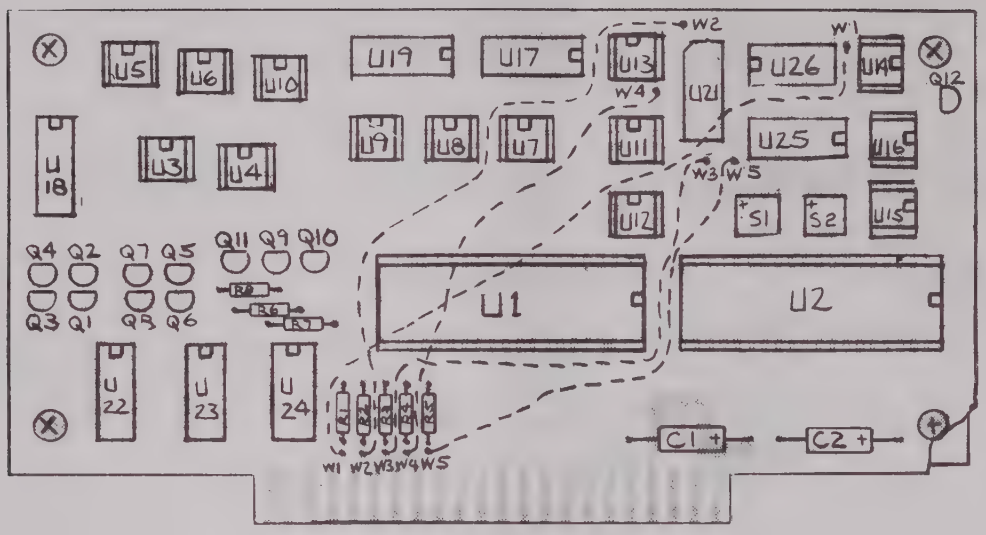


Figure B-1. Part No. 42132

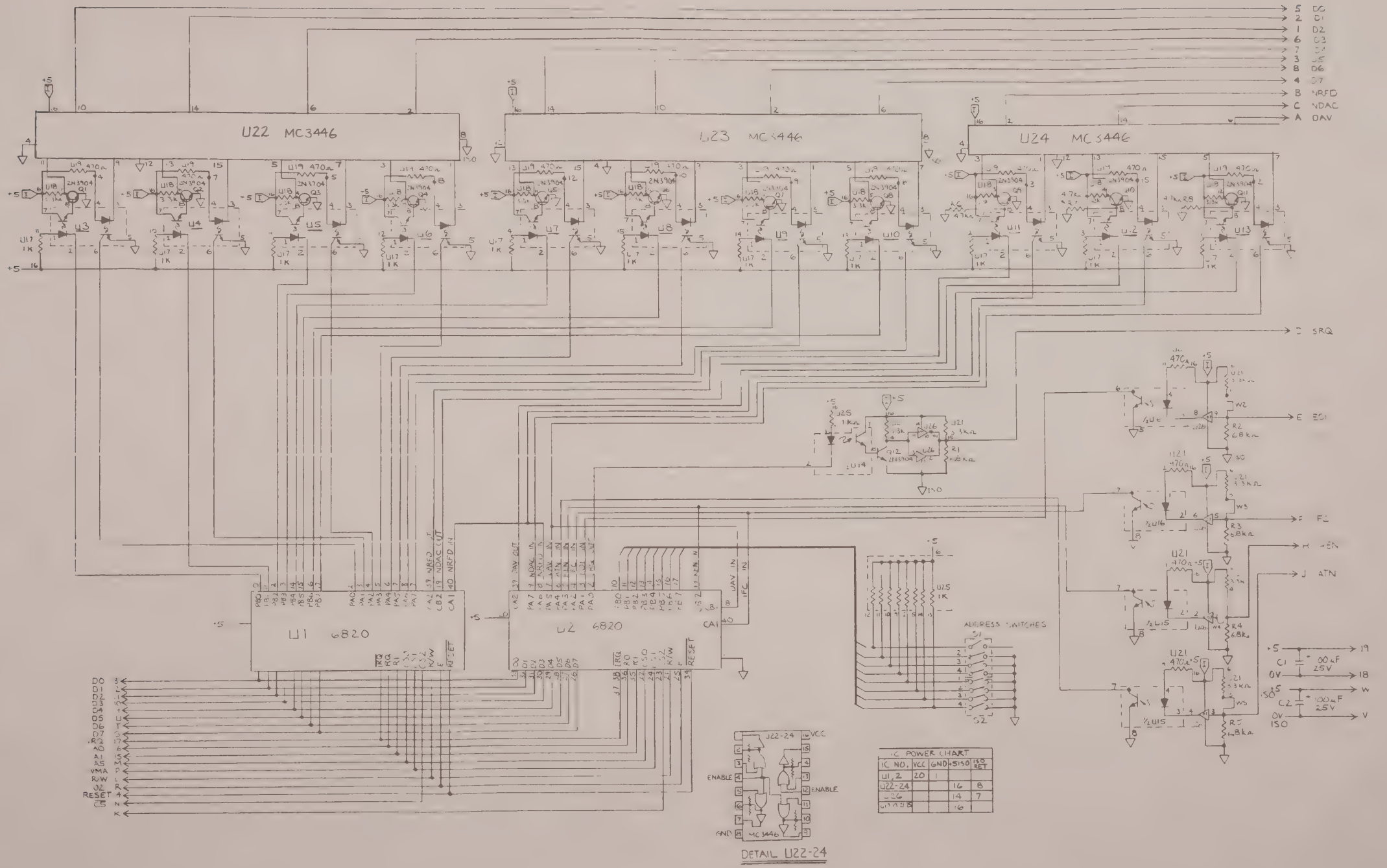


Figure B-2. Part No. 42132

B.2 Teletype Interface Circuit Assembly (Part No. 42763)

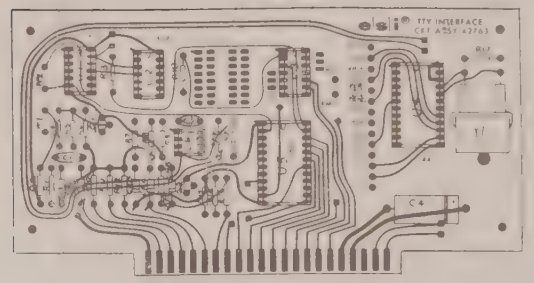
CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 0.1µF, Disc, 100V	24395
C3	Capacitor, 8pF, Disc Ceramic	02127
C4	Capacitor, 100µF, 25V, Electrolytic	13683
CR1-7	Diode, 1N4005	01779
Q1, Q2	Transistor, 2N3904	18751
R1, R2, R5, R6, R10, R11	Resistor, 1kΩ, 1/4W, 10%	13920
R3, R9, R14, R18	Resistor, 2.2kΩ, 1/4W, 10%	13924
R4	Resistor, 1.5kΩ, 1/4W, 10%	13922
R7	Resistor, 120Ω, 1/4W, 10%	13908
R8	Resistor, 6.8kΩ, 1/4W, 10%	13930
R12	Resistor, 100Ω, 1/4W, 10%	13907
R13	Resistor, 10kΩ, 1/4W, 10%	13933
R15	Resistor, 4.7kΩ, 1/4W, 10%	13927
R16	Resistor, 3.9kΩ, 1/4W, 10%	13929
R17	Resistor, 15MΩ, 1/4W, 10%	13976
U1	IC, 7406, TTL	20678
U2	IC, 7404, TTL	20695
U3	IC, 7400, TTL	20600
U4	4411, Baud Rate Gen	42933
U5	6850, ACIA	42968
U6	Op Amp, 301	20669
Y1	Crystal, 1.8432MHz, 0.05%	43268
	Socket, 24 Pin	41492
	Socket, Crystal, HC6-U Size	24444
	Socket, 8 Pin	22410
	Socket, 14 Pin	19189

NOTES:

1. SOFTWARE MUST BE WRITTEN FOR ÷16 CLOCK IN ACIA.
2. J1 INSTALLED FOR TTY (20 MA LOOP). J2 INSTALLED FOR RS 232. NO JUMPER INSTALLED FOR TTL.
3. ALL RESISTORS ARE ¼ W 10% & IN OHMS UNLESS OTHERWISE SPECIFIED.
4. ALL CAPACITORS ARE IN µF UNLESS OTHERWISE SPECIFIED.

	RS232	TTL DATA	TTY DATA
MARK	-12	+5	20MA
SPACE	+12	Ø V	Ø MA

BAUD RATE	FREQUENCY
9600	[illegible]
7200	[illegible]
4800	[illegible]
3600	[illegible]
2400	[illegible]
1800	[illegible]
1200	[illegible]
600	9600
300	4800
200	3200
50	2400
34.5	2583.3
09.9	1758.9
75	200



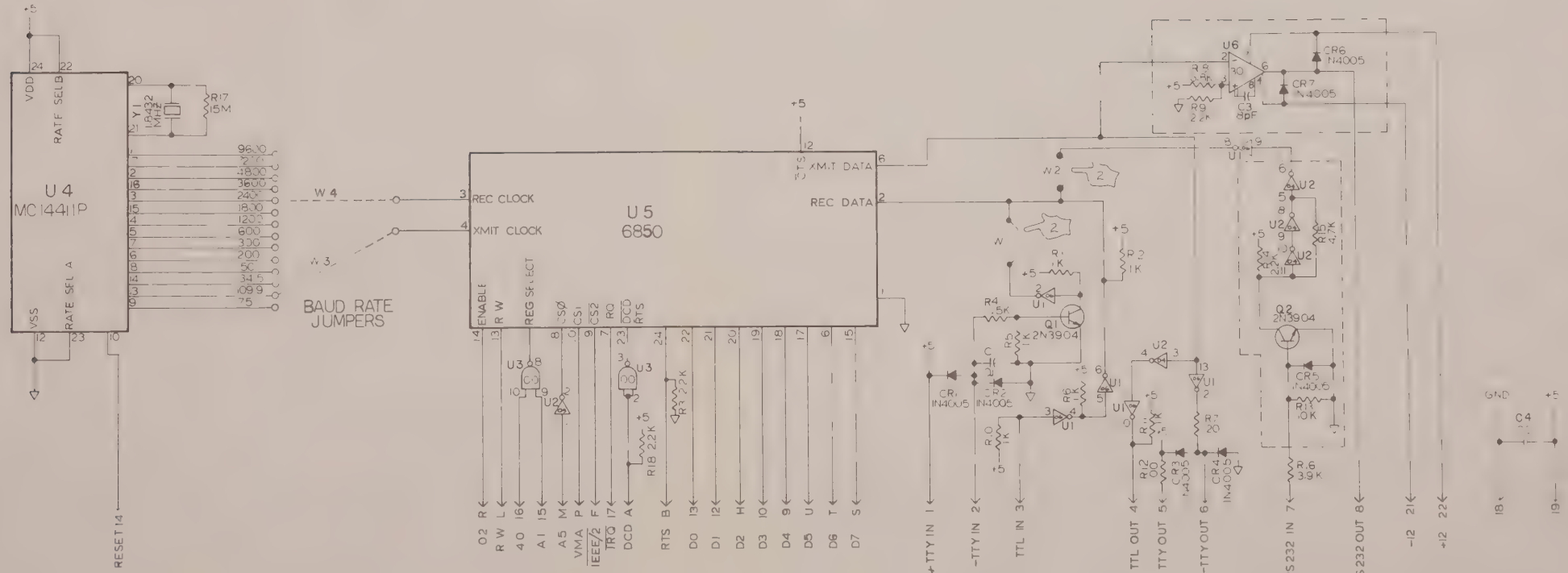
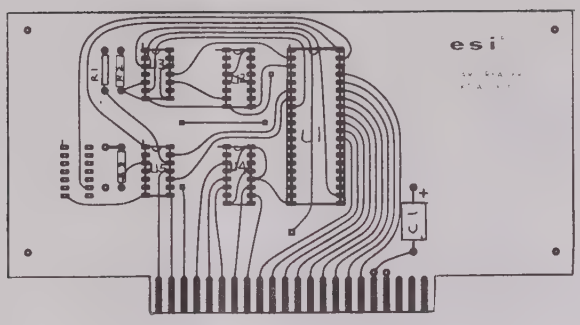


Figure B-3. Part No. 42763

B.3 Card Reader Interface Circuit Assembly (Part No. 43399)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 6.8µF, Tant, 35V	25339
R1-R3	Resistor, 3.3kΩ, 10%, 1/4W	13926
U1	IC, 6820, PIA	41292
U2, U4	IC, 7423	43845
U3	IC, 7400	20600
U5	IC, 7402	20604
	Socket, 40 Pin DIP	41342



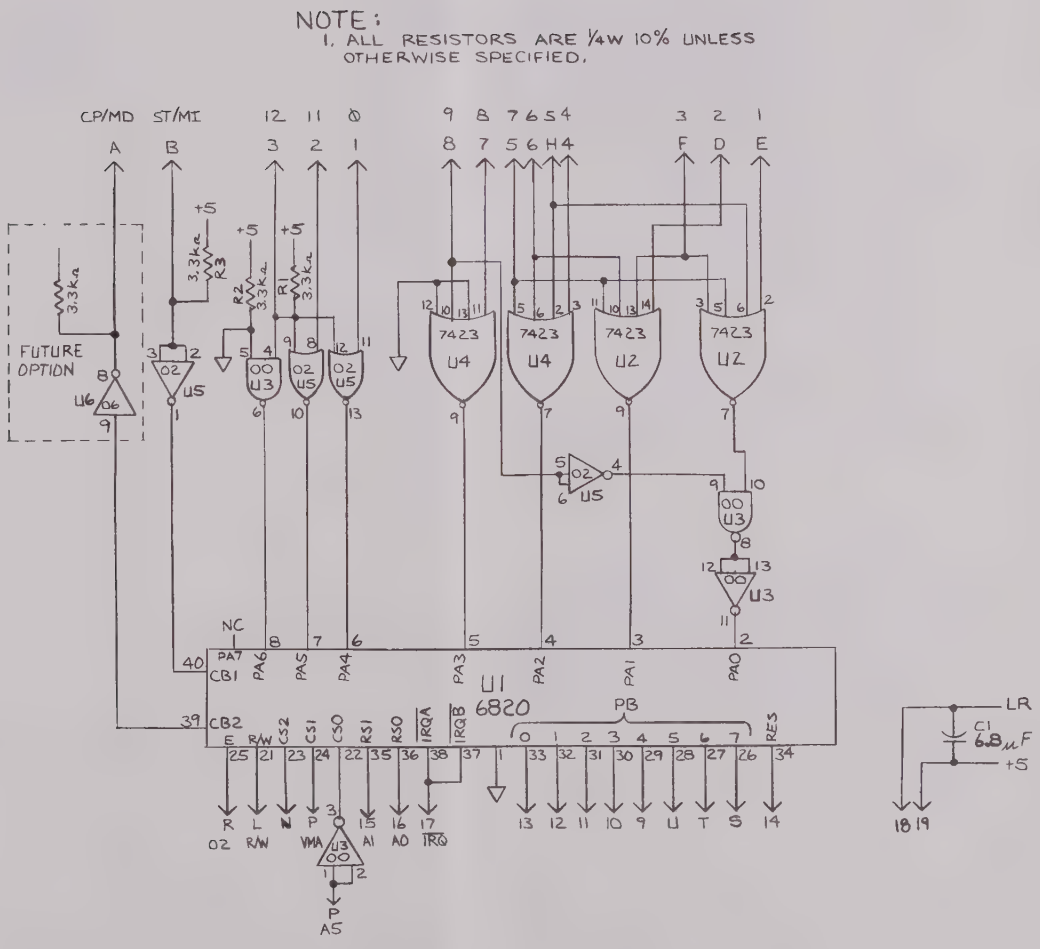
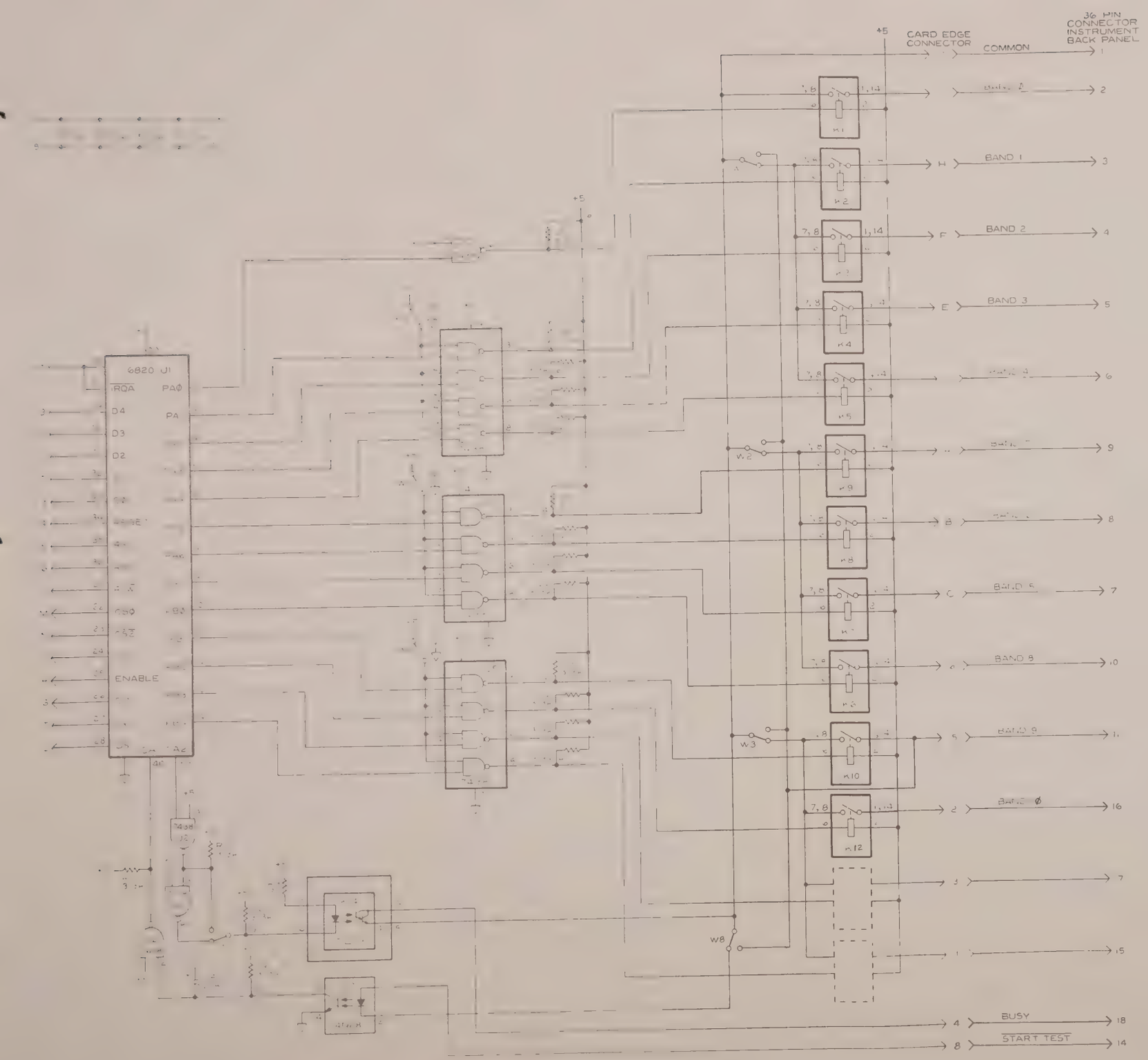
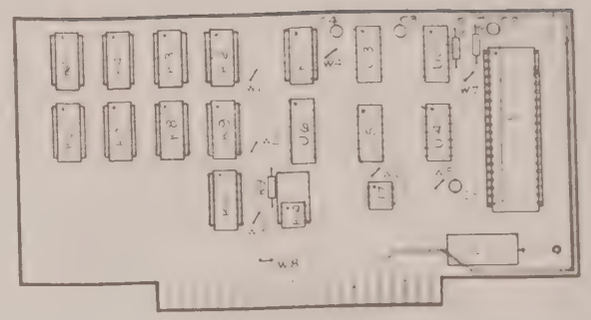


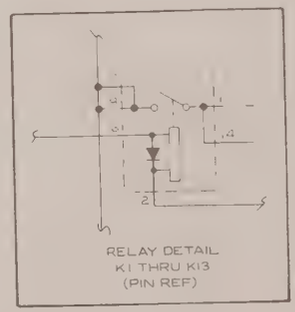
Figure B-4. Part No. 43399

B.4 Optional Interface Circuit Assembly, Engineered Automation, (Part No. 42073)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 100µF, 25VDC, Elect	13683
C2-C5	Capacitor, 6.8µF, Tant	43792
K1-K10,K12	Relay, GB821A-4	24804
K14	Optical Isolator, TIL119	44224
R9	Resistor, 120Ω, 10%, 1/4W	13908
R10, R11	Resistor, 3.3kΩ, 10%, 1/4W	13926
U1	IC, 6820, MOS, 40 Pin	41292
U2-U5	IC, 7433	20718
U6	Resistor Pack, 3.3kΩ, DIP	22947
U7	Optical Isolator, 4N28	20674
W1-W8	Wire, Bus, #22	06091
	Socket, 14 Pin DIP	19189
	Socket, 40 Pin DIP	41342







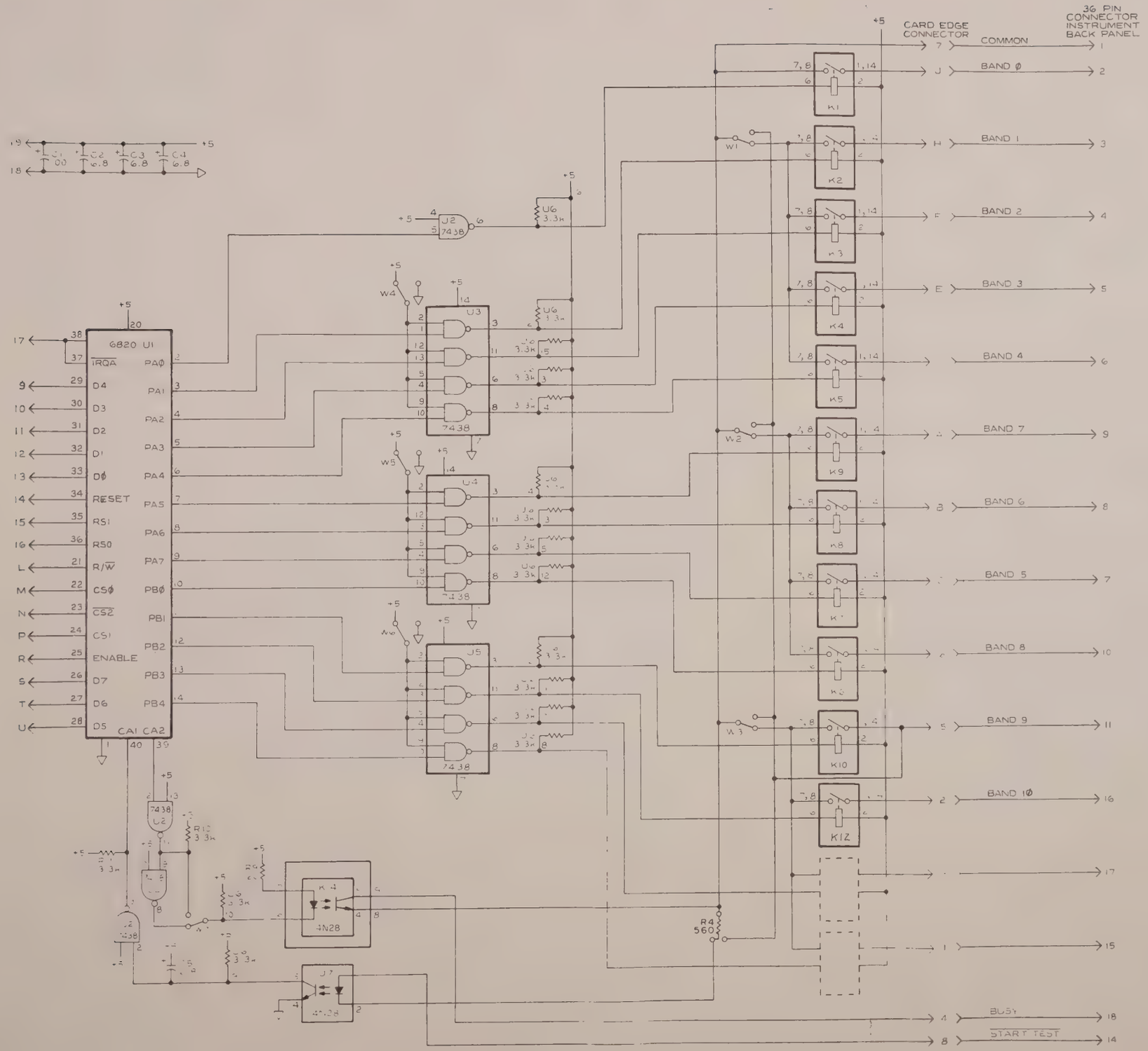
NOTE:

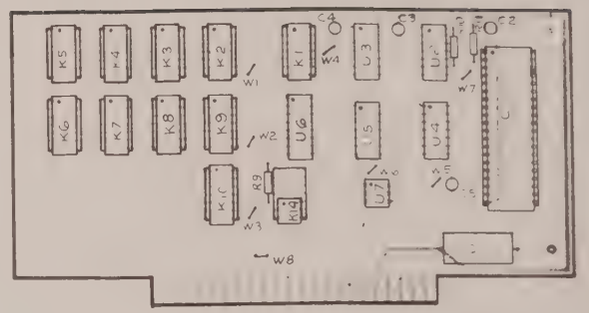
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.
3. SEE LIMITS SECTION OF INSTRUMENT MANUAL FOR DESCRIPTION OF THESE FUNCTIONS.

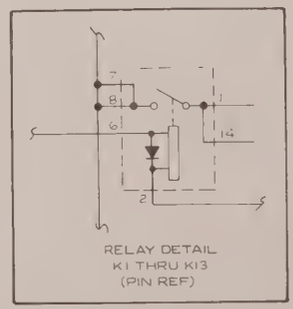
Figure B-5. Part No. 42073

B.5 Optional Interface Circuit Assembly, Daymarc, (Part No. 44256)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 100µF, 25VDC, Elect.	13683
C2-5	Capacitor, 6.8µF, Tant	43792
K1-10,K12	Relay, GB821A-4	24804
R4	Resistor, 560Ω, 10%, 1/4W	13916
R9	Resistor, 120Ω, 10%, 1/4W	13908
R10,11	Resistor, 3.3kΩ, 10%, 1/4W	13926
U1	IC, 6820, MOS, 40 Pin	41292
U2-U5	IC, 7438	20718
U6	Resistor Pack, 3.3kΩ, DIP	22947
U7,K14	Optical Isolator, 4N28	20674
W1-W8	Wire, Bus, #22	06091
	Socket, 14 Pin DIP	19189
	Socket, 40 Pin DIP	41342







RELAY DETAIL
K1 THRU K13
(PIN REF)

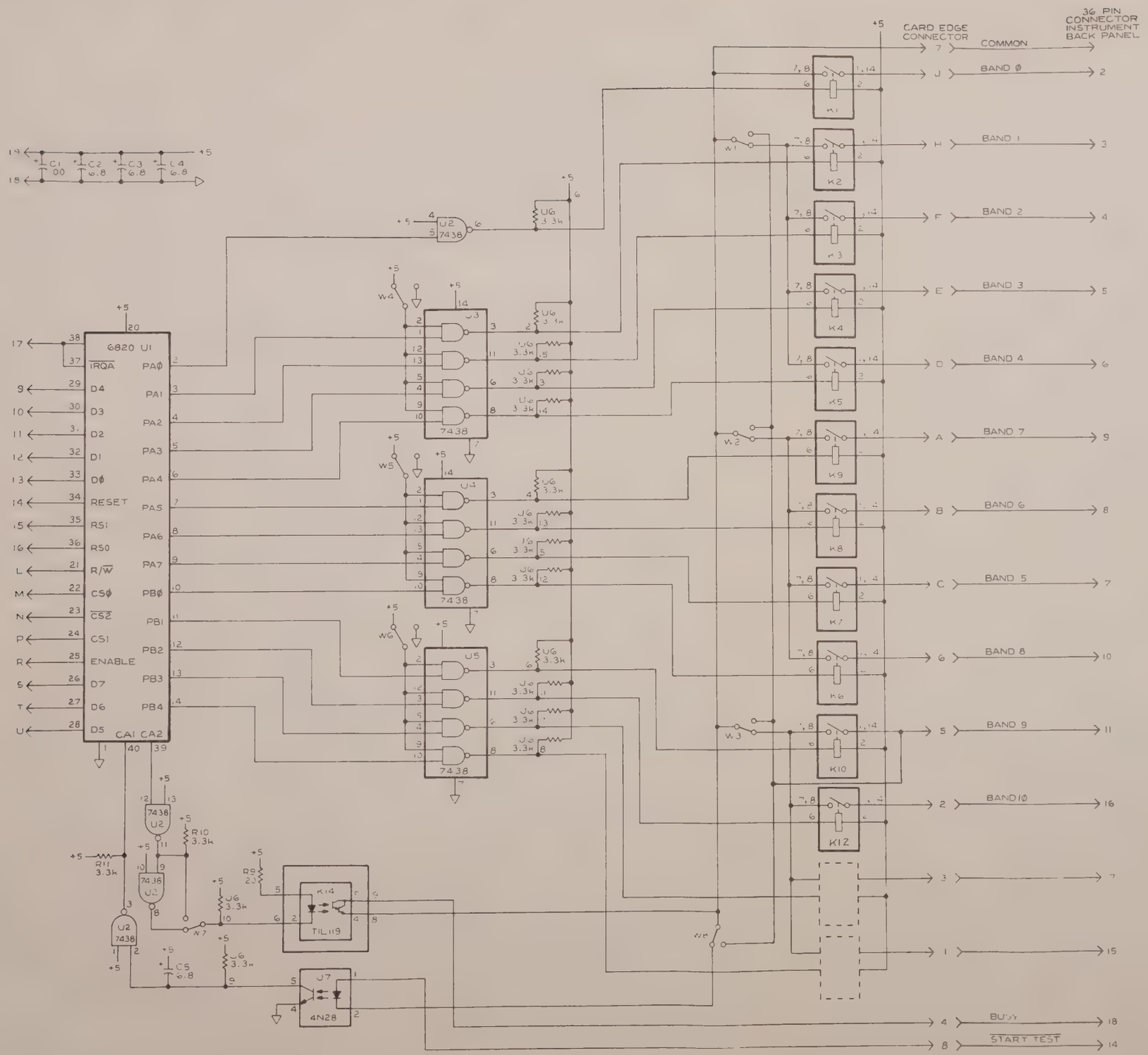
NOTE:

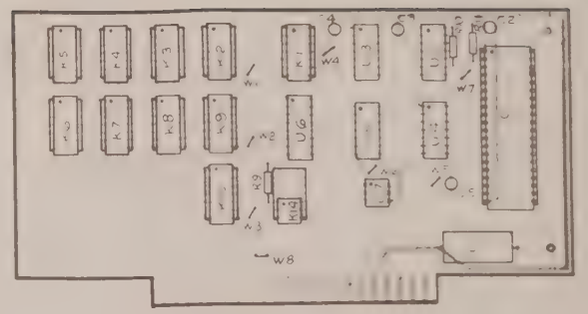
1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10%. UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.
3. SEE LIMITS SECTION OF INSTRUMENT MANUAL FOR DESCRIPTION OF THESE FUNCTIONS.

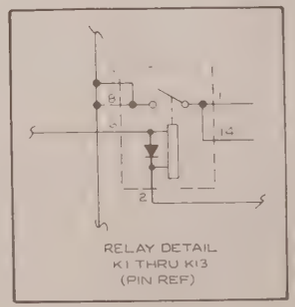
Figure B-6. Part No. 44256

B.6 Optional Interface Circuit Assembly, Deval, (Part No. 44257)

CIRCUIT NO.	DESCRIPTION	ESI PART NO.
C1	Capacitor, 100µF, 25VDC, Elect	13683
C2-C5	Capacitor, 6.8µF, Tant	43792
K1-K10,K12	Relay, GB821A-4	24804
K14	Optical Isolator, TIL119	44224
R9	Resistor, 120Ω, 10%, 1/4W	13908
R10, R11	Resistor, 3.3kΩ, 10%, 1/4W	13926
U1	IC, 6820, MOS, 40 Pin	41292
U2-U5	IC, 7433	20718
U6	Resistor Pack, 3.3kΩ, DIP	22947
U7	Optical Isolator, 4N28	20674
W1-W8	Wire, Bus, #22	06091
	Socket, 14 Pin DIP	19189
	Socket, 40 Pin DIP	41342







NOTE:

1. ALL RESISTOR VALUES ARE IN OHMS, 1/4W, 10% UNLESS OTHERWISE STATED.
2. ALL CAPACITORS ARE IN μF UNLESS OTHERWISE STATED.
3. SEE LIMITS SECTION OF INSTRUMENT MANUAL FOR DESCRIPTION OF THESE FUNCTIONS.

Figure B-7. Part No. 44257

Electro Scientific Industries, Inc.

13900 NW Science Park Drive
Portland, Oregon 97229
Phone (503) 641-4141
Telex 36-0273

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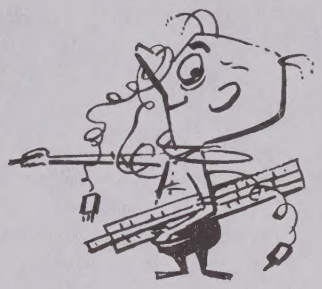

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- applications data
- technical articles
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☐ EB10 Effects of Output Loading on Resistive Voltage Dividers, *October 1969*

☐ EB15 Low Input Resistance Voltage Dividers, *February 1970*

☐ EB17 Accuracy vs. Frequency of Models 290B and 250DE Universal Impedance Bridges, *(revised May 1969)*

☐ EB26 International System of Units, *August 1969*

☐ EB29 DC and Low Frequency AC Ratio Measurements, *Dr. Merle L. Morgan, September 1962*

☐ EB30 Traceability of Resistance Measurement, *Jack Riley, January 1964*

☐ EB34 Resistance Transfer Technique, *Lawrence H. White, (revised April 1968)*

☐ EB35 An Improved Technique for Establishing Resistance Ratios, *R. M. Pailthorp and J. C. Riley, November 1962*

☐ EB41 Derivation of Electrical Units from Fundamental Standards, *R. D. Kuykendall and R. M. Pailthorp, July 1964*

☐ EB44 DC measurements Using Ratio Techniques, *Jack C. Riley, September 1965*

☐ TA2 A Ratio Transformer Bridge for Standardization of Inductors and Capacitors, *D. L. Hillhouse and H. W. Kline, August 1960*

☐ TA6 The Accuracy of Series and Parallel Connections of Four-Terminal Resistors, *Jack C. Riley, April 1965*

☐ TA8 AC Measurements Using Ratio Techniques, *Jack C. Riley, May 1965*

☐ TA14 The Advantages of a Ten Kilohm Transportable Resistance Standard, *Robert M. Pailthorp, September 1967*

☐ TA16 Which Bridge for Precise Resistance Measurements? *Edward J. Swenson and George D. Vincent, December 1967*

☐ TA17 Experimental Verification of the Five-Terminal, Ten-Kilohm Resistor as a Device for Dissemination of the Ohm, *R. M. Pailthorp and George Vincent, December 1968*

☐ TA22A Laser Resistance Trimming from the Measurement Point of View, *Arthur G. Albin and Edward J. Swenson, June 1971*

☐ TA23 Precision Measurement of Resistor Networks, *Robert M. Pailthorp and Jack C. Riley, June 1971*

☐ TA24 Predictive Adjustment of Tantalum Film Resistors by Anodization, *Donald R. Cutler and Edward J. Swenson, July 1971*

☐ TA25 Laser Trimming Analysis Using a Resistive Sheet Analogy, *Swenson, Vincent, Riley, December 1972*

☐ TA26 The Effects of Laser Trimming on Birox and 1100 Series Thick Film Composition, *N. S. Spann, R. Headley, G. D. Vincent and E. J. Swenson, October 1971*

☐ TA27 Laser Trimming Thin Film Precision Resistor Networks with an Automated System, *Leonhard Groth, January 1974*

☐ TA28 YAG Laser Trimming of Thick Film Resistors, *Headley, Popowich, Anders, January 1974*

☐ TA31 A Method of Obtaining Optimum Trimming Performance from a Laser System, *Paul F. Parks and Thomas W. Richardson, October 1974*

☐ TA32 Laser Trimming RC Active Filters, *Edward J. Swenson, April 1978*

☐ TA33 Reducing Post Trim Drift of Thin Film Resistors By Optimizing YAG Laser Output Characteristics, *June 1978*

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